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WORKING PAPER
ALFRED P. SLOAN SCHOOL OF MANAGEMENT

Diffusing Innovations When the Users are not
the Choosers: The Case of Dentists

by

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WP1413-83

March 1983

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Abstract

In the flow of innovations from supplier to user, many professionals serve as intermediaries, selecting on the basis of their particular expertise new technologies and products for the ultimate users. Using dentists as an example, this paper explores a number of issues this diffusion situation raises regarding new product development and dissemination.

Introduction

Diffusion and marketing models for consumer products generally rest upon some assumptions about the nature of the innovation adoption decision and about the relationship between the innovation manufacturer or supplier and the ultimate users of the innovations (Kotler, 1976; Rogers with Shoemaker, 1971). In the traditional diffusion paradigm, an individual decision-maker (1) becomes aware of a new product, service or technology, (2) seeks

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*The author is grateful for the Whitaker Health Sciences Fund grant which made this research possible.

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information about the innovation (often from interpersonal sources of communication) and, after considering the relative advantages of the new over the old, (3) decides whether or not to adopt. The benefits of a positive decision presumably accrue to that individual decision-maker and the decision to innovate is regarded as a wise choice if the adopter is satisfied with those benefits. User dissatisfaction with an innovation is conveyed back to the innovation suppliers either directly in the form of complaints or indirectly, but very effectively, by discontinuance and slowed or halted diffusion rates. See figure 1, A.

Recently, especially because of interest in problems of implementation (Tornatzky et al, 1979; Scheirer, 1982), researchers have realized that the user of an innovation is not always the chooser of it. There are countless examples of professionals who serve as intermediaries in the diffusion process, screening new technologies for less informed or sometimes just less powerful users. In the purchase of office automation equipment, managers select products which affect the working conditions, working style, rewards and satisfaction levels of other people far more than the technology affects them personally. In the case of doctors deciding upon medical innovations, or officers selecting technical equipment for soldiers, the choice made by the intermediary, the "chooser," impacts the user even more dramatically; the choice may significantly affect the user's chances for survival. While in some areas of our society, we are moving towards more user participation in the choice of innovations which affect their lives (e.g., gynecology and types of divorce law), in others, we are empowering whole new classes of experts or intermediaries (e.g., in computer applications).

The diffusion process involving an intermediary is somewhat like the industrial buying situation, in which the purchase decision involves a

A. When the Chooser is also the User

B. When the Chooser is Not the User

Figure 1: The Diffusion of Innovation
Under Two Diffusion Conditions

number of individuals, each with a different background, perspective, and consequently, a different product demand (Choffray and Lilien, 1980; Webster, 1979). Marketers of new industrial goods and services thus have to please multiple market segments simultaneously with one product. The diffusion situation described in this paper differs even from an industrial setting, however, in that the peculiar relationship between professional and client serves to obscure those market segments. Innovation suppliers do not have to respond (indeed are cut off from understanding) end-user needs.

In these diffusion situations, when the chooser rather than the user goes through the decision stages of awareness, evaluation and adoption or rejection, the flow of both the innovation itself and information on its use pass through the intermediary. See Figure 1,B. This screening function of the intermediary shapes not only the diffusion process (and consequently diffusion or counter-diffusion strategies) but the innovation itself. An innovation is not always, or even usually, constant in form as it diffuses (Rogers and others, 1977). Even technical products evolve as they diffuse (Leonard-Barton, forthcoming). Feedback from users, from the market, influences the incremental improvements made in the innovation. However, if that information based on user experience with the innovation characteristics reaches the suppliers only through an intermediary, and that intermediary's criteria for judging the innovation differ from those of the ultimate user, the supplier will receive incomplete information. Changes made in the innovation will conform to the needs of the chooser, and to those of the user only as reflected by the intermediary. The flow of information about the innovation can be constricted in the opposite direction, from supplier to user, as well. The intermediary passes on to the user only such information about the innovation as he believes the user needs or desires. The more technically sophisticated is the innovation, the

less inclined the intermediary is to share information with, or as he may perceive it, burden with information, the user (Nochur, 1982).

The situation involving an intermediary, then, affects the diffusion process in two important ways: First, less and less information about the innovation is available as it moves from supplier to user. Adoption decisions made upstream are usually invisible to the ultimate user, who does not even know what options have already been foreclosed (Figure 2).

Secondly, the user does not always want to be heavily involved in the evaluation of an innovation, even if he is the ultimate recipient of it. Nor, consequently, are his needs for technical information always high. In fact, depending on his level of technical expertise, the user needs more information about the technology selector, the intermediary, than he does about innovation itself. This hypothesized relationship is pictured in Figure 3. In the case of dentistry, most patients fall into the lower left quadrant of the graph; that is, they are rarely in a position to judge the relative merits of a new material or technique. Instead, they seek information about the intermediary, to try and find a dentist whose criteria for good workmanship (and therefore for the adoption of new products and processes) match their own.

Description of the Research

Intermediaries in the diffusion of medical technologies have a particularly significant role, for a number of reasons. Medical innovations are so specialized that users rarely possess the expertise to evaluate the choices made for them. Secondly, almost everyone in the general populace is affected at some time in his or her life by the technology selection of a medical professional. Third, the choices made directly and obviously affect

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FIGURE 2

Figure 3
Hypothesized Relationship Between User Expertise
and Desire for Involvement in Innovation Decision

the health of the user, and consequently are often of greater concern to them than choices made by other intermediaries. The research reported here focuses on prosthodontists--those dentists who specialize in fixed restorations (e.g., crowns and bridges). The study is designed in three phases, the foci of which generally correspond to the following questions:

1. What major innovations have been introduced into the profession during the past 20 years?
2. What criteria do prosthodontists use in evaluating innovations? (How do these criteria compare to patients'?)
3. What influences (including information and training sources) shape those criteria?

In the first phase, 20 crown and bridge experts were interviewed on the east and west coasts. From the data gathered in these personal, in depth interviews and from analysis of professional literature, we identified the relevant population of innovations to be studied and the major criteria used in evaluating innovations.

The second phase of the research consisted of a one-page questionnaire included in a regular membership mailing to the 300 U.S.-based members of the Academy of Crown and Bridge, asking for evaluations of the innovations on 21 characteristics. Since the Academy would not release their membership list, no follow-up was possible to this one-time mailing.¹ At the same time, 52 Cambridge, Massachusetts dental patients were interviewed by telephone about their experience with dentists and their evaluation of dental innovations.

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¹ Of the 97 responses received, seven were from retired members (including several well over 80 years old) who disqualified themselves from the survey. Presumably, many more retirees and otherwise unqualified recipients did not bother to return the forms. Therefore the response rate of 31% (calculated on the base of 293) almost certainly understates the response from qualified members.

The final question as to what influences shape the dentists' evaluations, is being addressed in the third phase of a study, a nation-wide survey of a random sample of members of the American College of Prosthodontists and of the American Prosthodontic Society (N=300). The same questionnaire has also been administered to 80 percent of the approximately 75 prosthodontists in the greater metropolitan Boston area, with a special section requesting information about their professional interpersonal networks (the other prosthodontists with whom they talk and from whom they learn new techniques).

The Pilot Study

The Innovations Studied

The innovations selected for study vary along several dimensions (See Table I):

1. Type (e.g., equipment; material; technique).
2. Scope (i.e., degree to which innovation represents a minor or major change in routine).
3. Age (i.e., time since first introduction into industry).
4. Diffusion level (i.e., how widely used in the industry as a whole).

The variance in the last dimension (extent of use) is a function of the first three dimensions. Some of the innovations are adopted primarily as a matter of personal preference; their adoption impacts practice and patients very little. For instance, the hydrocolloid and vinyl polysiloxane impression materials, used to make casts of the mouth prior to the construction of a crown or bridge, differ somewhat in consistency, taste,

TABLE I

Description of Innovations and Their Ranking in Usage
by Members of the Academy of Crown and Bridge (N = 90)

<u>Rank Order</u>	<u>Innovation</u>	<u>Description</u>	<u>Mean Use Level</u>
1	Air Drill	High speed hand drill (equipment)	3.0
2	Gold fused to Porcelain	Precious metal fused to porcelain for natural-appearing crowns and bridges.	2.9
3	Acid-etching	Process of micro-etching to create more porous base for subsequent bonding.	2.7
4	Hydrocolloid	Material used to take impressions of patients' mouths prior to the construction of a crown or bridge. Replaces rubber.	2.6
5	Fully Adjustable Articulator	Device for measuring and duplicating the movement of the patients' mouth in three directions, used to guide restoration construction.	2.1
6	Vinyl Polysiloxane	New impression material; replaces rubber. (See hydrocolloids, above.)	1.9
7	Non-precious alloys fused to porcelain	Base metal alloys, usually nickel-chromium, traces of other metals, fused to porcelain for crowns and bridges.	1.8
8	Polycarboxylate cement	Quick-setting polyacrylic acid and zinc oxide bonding material.	1.7
9	Vitreous carbon implant	Glassy carbon material secured in the jawbone to which one or more artificial teeth can be attached.	1.4
10	Glass Ionomer Cement	Translucent bonding material used in restorations.	1.4
11	Blade Implant	Metal implanted in the jawbone as a basis for one or more artificial teeth.	1.2
12	Subperiosteal Implant	Metal framework attached to the jawbone as a basis for artificial teeth.	1.2

^aTwo other innovations included in the original survey were dropped from the analysis because they were found to have limited relevance to the population surveyed. These were: (1) pit/fissure sealants, and 2) the fluid resin technique.

^bRange: 1 = Never use; 3 = Use a lot.

rapidity of setting and accuracy. However, the materials do not stay in the patient's mouth and a reasonably skilled practitioner can achieve comparable results with either material. Therefore switching to either of these materials from their predecessor technology, rubber, is a relatively minor decision.

Other innovations involving the use of materials which are part of a permanent restoration, such as the cements, impact the patient very directly and thus the decision to use them presumably requires more careful consideration.

Still others, such as the substitution of non-precious metal alloys (chromium, nickel and beryllium mixtures), for gold/palladium alloys fused to porcelain in crowns, are regarded as quite controversial by dentists. Not only do the physical characteristics of the non-precious metals differ from those of the gold (raising the issue of adoption beyond a matter of mere preference) but the benefit and even the safety of those properties are in considerable dispute.² Thus, the adoption of non-precious metals is not a trivial decision.

The role of the intermediate adopter (who serves as a kind of gatekeeper in the flow of information and product from supplier to end user) would be irrelevant if the incentives, rewards and desires which drive his technology choice were identical to those of the end user. Of course, they are not.³ In the case of responsible professionals, there must be some

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² The Ralph Nader-associated Health Research Group called attention to beryllium hazards in 1974 and after citing such studies as existed on the topic, the group called for much more scientific evidence before FDA cleared non-precious alloys containing beryllium. They suggested that beryllium could be harmful to dentist and patient as well as lab technician (Wolfe and Horicko, 1974).

³ Marketing scholars writing about industrial buying have long recognized that the choice of an industrial product is influenced by a number of actors in the firm besides the ultimate user. See, for example, Robinson, Faris and Wind (1967), Choffray and Lilien, 1980).

overlap between the two sets of choice criteria, or else the intermediary would lose the patronage of the ultimate users. However, even in the case of such client-sensitive intermediaries as dentists, the overlap is far from complete. Moreover, the professionals and the clients differ in the relative importance they would assign to those product characteristics which they both desire.

Dentists' Criteria for Adopting Innovations

In the one-page form sent to the Academy of Crown and Bridge members, prosthodontists were asked to evaluate the 14 selected innovations by 21 characteristics (e.g., how risky, how cost-effective, how clinically tested they believe the innovation is, etc.) and to indicate the degree to which they use each innovation (Table II). Most of the findings reported in this paper are derived from this Pilot Stage of the research.

Intuitively, one would expect that the more controversial an innovation is, the less widely diffused it is. Indeed, as Table II (# 9) indicates, adoption levels are negatively related to perceptions of how controversial the innovation is, in all six cases for which any significant relationship is found.⁴ One would also expect to find the rate of diffusion negatively related to the controversial nature of the innovation. While we have not tracked the diffusion of these innovations over time, we do know approximately when references to four of them started appearing in the literature.

As Table III shows, the rate of diffusion of each innovation (calculated simply as the current use level among Academy of Crown and Bridge members, divided by the number of years since the innovation started appearing in the

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⁴ In all other innovations, the relationship between use and controversy is negative, but fails of significance at the $p < .05$ level.

TABLE II

Relationship Between the Characteristics of Innovations
and Their Usage. (Kendall's Tau)^a (N = 90)

Characteristic of the Innovation (as perceived by dentists)	Articulator	Blade Implant	Vitreous Carbon Implant	Non-precious Alloys	Gold Alloys	Acid-etching	Glass Ionomer Cement	Polycarboxylate Cement	Vinyl Polysiloxane	Hydrocolloids
1. Status in Dental Prof.	.28**	.30*	.20	.24*	.19*	.33**	.21**	.32**	.30*	.21**
2. Advantage	.31**	.25	.41**	.41**	.23*	.33**	.50**	.53**	.48**	.52**
3. Benefits to Patient	.53**	.48**	.35**	.61**	.23*	.35**	.45**	.47**	.40**	.31**
4. Works (success/failure)	.38**	.42	.46	.46	.18*	.47**	.39**	.41**	.40**	.22*
5. Impact	.30		.17	.17	.29*	.23	.26	.28*	.29*	.22*
6. Widely accepted	.21**	.27*	.35**	.35**	.29*	.36**	.17	.37**	.27*	.21**
7. Range of use	.30*		.30*	.30*	.32*	.35**	.32*	.23*	.50**	.52**
8. Easy to use	.26		.28*	.28*	.28*	.28**	-.24*	-.24*	-.41*	-.30**
9. Controversial		-.27*	-.47**	-.47**	.33**	-.62	.28	.29*	.29*	.18
10. Cost-effective-Patient	.25*		.29*	.29*	-.35**			-.32**	-.32**	
11. Old fashioned	-.18	-.19	-.58**	-.58**		-.39**	-.24*	-.38**	-.38**	
12. Risky		-.25*	-.55**	-.55**		.35**		-.39**	-.39**	.35**
13. Clinically tested	.23*	-.31*	.36	.36	.24*	-.34		.39**		
14. Radical	-.17		-.42	-.42					.25*	
15. Cost-effective-Dentist	.27*		.27*	.27*		.34**	.23*		.23*	
16. Written up in lit.	.25*		-.22	-.22				-.42**	-.42**	
17. Fadish		-.30*			.31**	.18		.33**	.33**	
18. Promoted			.33**							
19. Patient demand		.20								
20. Requires skill		.18								
21. Requires training										

a The Kendall's Tau here is a non-parametric measure of the correlation between the dentists' use of each innovation and their evaluations of that innovation on this particular characteristic, measured on a range of 1 to 3, where 1 = very low on that characteristic and 3 = very high.

Significance levels: $p < .05$; $p < .01$ *; $p < .001$ **

TABLE III
Diffusion Rates for Selected Dental Innovations
Among Prosthodontists (N=90)

<u>Innovation^a</u>	<u>Approximate Time First in Literature</u>	<u>Use Level</u>	<u>Diffusion Rate^b</u>	<u>Rating on "Controversial"^c</u>	<u>Rating on "Risky"^c</u>
Blade Implant	1957	1.2	.050	2.9	2.7
Fully Adjustable Articulator	1955	2.1	.080	2.1	1.3
Glass Ionomer Cement	1973	1.4	.175	2.0	1.8
Acid-etching	1967	2.7	.225	1.3	1.4

^a See Table I for a description of these innovations.

^b The diffusion rate is a simple average: number of years since introduction into literature divided into the current level of use among the prosthodontists in our Pilot Study sample of Academy of Crown and Bridge members.

^c Range: 1 to 3, where 1 = very low on this characteristic and 3 = very high.

literature) is indeed inversely related to the amount of controversy surrounding that innovation. The level of risk associated with use of the innovation is also inversely related to the diffusion rate for three of the four innovations in Table III; the exception, the fully adjustable articulator, is a very expensive piece of equipment requiring a great deal of skill, but its use does not constitute risk for patient or dentist. In general, it would seem that controversy slows the rate of innovation diffusion.

As Table IV (which summarizes the more detailed data of Table II) shows, some attributes appear to be generally important, that is, they are related to usage across a wide range of innovations. Other characteristics distinguish between adopters and non-adopters of only a few new technologies. Eleven of the attributes are evidently important in judging six (over half) of the innovations finally selected for analysis, since the evaluations correspond to usage patterns; i.e., high use levels are associated with high attribute ratings.⁵

As an examination of the characteristics desired by dental patients will show later in this paper, most of the attributes dentists use in judging innovations parallel those of their clients. As Table IV indicates, dentists appear to be using innovations which they regard as advantageous over previous practice (#2), beneficial to the patient (#3), successful (#4), and cost-effective (#10). However, the one attribute which is consistently related to use for all 10 innovations is the perceived level of status enjoyed by the innovation in the dental profession (#1). Of course

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⁵ Of course no certain causality can be inferred here. It is perhaps as plausible that the dentists first adopted the innovation and subsequently judged its attributes favorably as it is that initial favorable evaluations were followed by use (or unfavorable by rejection)

TABLE IV

Relationship Between the Characteristics of Dental Innovations and Their Usage: Summary Table (N = 90)

Characteristics of Innovations ^a	Number of innovations for which this characteristic distinguished among high and low users	Average Kendall's tau between use level and characteristics
1. Status in the dental profession	10	25.8
2. Advantage over previous practice	9	39.5
3. Benefit to patient	9	39.5
4. Success to failure ratio	8	39.4
5. Impact on dental profession	8	24.2
6. Widely accepted or not	7	27.4
7. Range of uses	7	33.6
8. How easy to use	6	30.8
9. How controversial	6	-38.5
10. How cost effective for the patient	6	27.0
11. How old fashioned it is	6	-31.0
12. How risky it is	5	-36.4
13. How well clinically tested	5	33.6
14. How radical it is	4	-31.0
15. How cost-effective it is for the dentist	4	24.8
16. How much it is written up in the literature		27.3
17. Fadish or not	3	-31.3
18. How much it is promoted by suppliers	2	25.5
19. How much patient demand there is for it	2	32.0
20. How much skill is required to use it	1	20.0
21. How much training is required to use it	1	18.0

- a. This table summarizes the information given in Table II. Four innovations included in the original survey were dropped from the analysis, two because they were found to have limited relevance to prosthodontists themselves (pit and pressure sealants and the fluid resin technique), one because it has been universally adopted (the air drill), and one (subperiosteal implant) because the data on it duplicate those on the better-known blade implant. This table covers 10 innovations.

dentists have a natural vested interest in believing that their choice of materials and techniques are well regarded by colleagues; therefore, they are likely to rate highly innovations they use a lot. However, the attribute of status is likely to be irrelevant to end users.

In contrast the attributes which are irrelevant to dentists' choice are: patient demand (#19), the degree of skill required (#20) and the amount of training necessitated by adoption of the innovation (#21). The lack of relationship between use levels and the last two characteristics, need for skill or training, is easily explained. Like other professionals, dentists are diffusion intermediaries precisely because their special training and skills differentiate them from end users. What diffusion intermediary would say that the adoption of an innovation in his/her profession requires little skill or training? Not surprisingly, then, dentists report little variance on this dimension among dental innovations. All innovations, they say, require skill and training.

The fact that patient demand is irrelevant may seem more surprising at first. This finding is not inconsistent with the dentists' selection of "patient benefit" as an important choice criteria, however. Patients, it is assumed, do not know what would benefit them. Such knowledge is the province of the professional. Dentists are also universally conscious of the fact that their patients are in no position to create demand for most innovations (Table IV, #19). "Patients don't know anything" dentists tell us repeatedly. Even more important, from the dentists' point of view, is that "patients don't care what I put in their mouths, so long as it lasts." Moreover, "most patients can't distinguish between materials -- not even gold and non-precious metals. If it looks yellow, they assume it is gold. If it looks gray, even if it is a gold/palladium (all-precious metal) alloy,

they think it's not gold." The fact that crowns and bridges are restorations which are highly visible to patients, plus the fact that there is often a small cost difference of about 5-8% to the patient between a non-precious and a gold crown,⁶ probably explains why some dentists in our sample believe there is some patient opinion about these two materials and therefore demand for one or the other (#19, Table II). However, patient demand is an irrelevant consideration for all the other innovations.

Patient's Criteria for Innovations

Patients do trust their dentists' judgements; four-fifths of our sample of dental clients said they trust their dentist "completely" (40%) or with only "a few questions" (39%) when he selects a product or process to use.

However, as one would expect, the patients' criteria for judging successful innovations are somewhat different from the dentists' (Table V). Patients are concerned with the fit and feel of tooth restorations (45%), and with the quality and durability of the material used (35% and 25% respectively). All of these characteristics might be considered part of the dentist's concern for "benefit to patient" and consequently of the "relative advantage" of the innovation for dentists. Patients are also interested in the cost (35%) which is importantly related to usage for six out of 10

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⁶ The cost difference to the dentist is sometimes considerably higher, depending on whether or not he has a close association with the dental laboratory where the crown and bridge work is done. If the dentist owns or works closely with the laboratory, the lab may pass the savings in materials on to the dentist. Because the non-precious material is more difficult to work with than gold, however, many laboratories charge almost the same price for work done in the lower cost materials as for gold. Using the same reasoning, some dentists charge patients the same for non-precious as precious metal restorations, regardless of any cost differential in materials to the dentists. the cost (35%) which is importantly related to usage for six out of 10 innovations judged by dentists (Table II). Aesthetics are also important to patients (25%).

TABLE V

Criteria Utilized by Patients in Determining Their
Satisfaction with Dental Work (N = 52)

Criterion	Percentage of Patient's selecting this criterion
How the restoration fits/feels	42.3% ^a
The quality of the materials	34.6
How much the work costs	34.6
How the restoration looks	25.0
How long the restoration lasts	25.0
The quality of the workmanship	5.8

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a. Percentages sum to more than 100% because of multiple responses.

innovations judged by dentists (Table II). Aesthetics are also important to patients (25%).

Asked what criteria they felt dentists applied to the selection of new materials and techniques, one-fifth of our respondents had no idea, but over half felt the dentist chose whatever was "best for the job." Naturally, consumers are not interested in the status of a new material among dentists, how widely accepted it is, its impact on the dental profession, nor how easy it is to use, although these are all relatively important criteria for dentists (Table II).⁷

Information About Innovations

As noted above, diffusion intermediaries not only monitor and influence the physical flow of innovations from supplier to user, but they also serve as the conduit for information about the innovations. The dental patients and prosthodontists surveyed have rather different perceptions of that information-screening role.

End users (patients in this case) tend to assume that information flows naturally as a part of the innovation introduction process. Almost all (92%) our consumer respondents say they want to be consulted beforehand if their dentist intends to use an innovation, but most either assume that he has never used a new material or technique on them (46.2%) or else they do

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7 The discrepancy between the views of the two groups of dental innovation "adopters," i.e., dentists and patients, is akin to the difference between innovation characteristics desired by different decision making groups in an industrial buying situation (e.g., top managers and production engineers; see Choffray and Lilien, 1980, Chapter 6). However, even top managers do not usually control information about and selection of the innovation the way a professional can.

not know whether he has or not (25%). Only 2% of the prosthodontists surveyed had made no changes in their practice in the past three years; almost half had introduced major innovations in materials or techniques. Therefore it would seem that the patients are underestimating the amount of new materials and techniques they have received or are overestimating the amount of information being conveyed to them.

Similarly, although 54% of the patient sample said that their dentist "always" voluntarily explains the techniques and materials he uses before beginning dental work, less than one-third of the prosthodontists said that they "always" tell a patient about what is going into a restoration even when they are trying out new materials.

The intermediaries and the ultimate users also disagree about the patients' need to know about what materials are being used. Half of the dentists (with another fifth choosing a non-committal "neutral" response) believe that the patients don't usually need to know, but only one-fourth of the patients agree. Similarly, about one half (46%) of the patients disagree with the statement "I don't care what materials my dentist uses, as long as the dental work is successful" whereas only one-fifth of the prosthodontists disagreed that "patients don't care what material I use, as long as the restoration works."

To judge from these samples of "choosers" and "users," there are fundamental differences between the two groups in both the characteristics of the technology they would desire (and which therefore they would demand from technology developers) and in the kinds and amounts of information they would regard as an integral part of the innovation diffusion process. These differences can lead to the inappropriate diffusion of innovations and consequent problems for all three major actors in the diffusion process;

suppliers, intermediaries and end users.⁸

As noted above, one of the most serious problems is that information as screened by intermediaries reaches end users in incomplete form. Professionals have a deep vested interest in protecting both the proprietary skills on which they base their fees and in protecting their own interests. On occasion, therefore, the flow of innovations to users is blocked by intermediaries who feel threatened by the new products or processes. For instance, a new sealant to prevent tooth decay among children has met with an unenthusiastic reception by some dentists, partly because the incidence of caries has already plummeted in the U.S., and with it, the need for dental services.⁹

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⁸ Much of this discussion applies also to the weak information link between dentist and the dental laboratory which actually fabricates the metal and porcelain crown. Although dentists theoretically prescribe the type of metal to be used, they rarely know more than the name of the alloy being used, if that. Dentists choose a laboratory which turns out consistently good casting, and that frequently means allowing the technician to choose the metal he works best with. Moreover, there is widespread confusion about the level of gold content in "semi" and "precious" alloys. Rarely do the doctors know the exact content of the metal used in the crowns and bridges (Decision Research Corporation, 1983; Leonard-Barton, forthcoming).

⁹ The advent of fluoride had an enormous impact on the dental profession; some dental experts believe this new sealant may have a similarly significant impact. See Gift (1981)

Similarly, when Boots Pharmaceuticals, Inc. started offering consumers a \$1.50 rebate on their product, in order to break into the lucrative antianthratic prescription drug market in the U.S., physicians objected strenuously, pointing out that the promotion tactic could "undermine physician control over prescribing" (Business Week, 1982).

However, intermediaries also block information or innovations out of a very legitimate concern that patients may demand inappropriate treatment. End users sometimes get partial information from media or from a few outspoken advocates of a new product or process, leading to exaggerated expectations from an innovation. In a case cited to us by a number of dentists, Dr. Leonard Linkow was featured on the "That's Incredible" television show because he had fitted host John Davidson with an implant. The dentists said patient demand was inappropriately stimulated by this show; people came in asking for implants who would be better served by a non-surgical, less radical, less invasive, and more permanent restoration. Yet, because the innovative technique avoids the stigma of "false teeth," the patients insisted. They placed a higher value on aesthetics than on other considerations. Many of our respondents felt the patients had been misled into unrealistic expectations for this very temporary measure and therefore into inappropriate adoption.

Occurrences of the first type of information blockage (intermediaries screening out information of potential benefit to users because it threatens them) undermine the professional's credibility in the second type of instance (intermediaries' attempts to protect patients from their own ill-informed enthusiasms). In both cases, the end user suffers the consequences of an inadequate information system.

Even more serious than the breakdowns in the flow of information to users, however, is the inadequacy of information feedback mechanisms from users, 1) to the intermediaries, and 2) to suppliers. (These flows are represented by dotted lines in Figure 2).

Because of the diffusion intermediaries position as experts, they not only control the flow of information, but they bear responsibility for monitoring the success or failure of the innovation. End users cannot make such evaluations. First of all, as previously noted, the recipients of an innovation are frequently totally unaware that they are "adopting" one.

Secondly, patients lack the expertise to separate failure of workmanship from failure of materials. Unable to ensure a satisfactory job through their own technical knowledge, they exercise control the only way open to them. Assuming they will get a better fit or improved aesthetics from a different practitioner, they simply move on.

The dentists, therefore, usually do not hear about adverse effects from work they themselves do, although dentists in our sample frequently mention poor work they see. It is almost always the other dentists' work they redo, and since differing levels of skill do affect the success of materials, even the dentist is not certain whether the innovator or the innovation is at fault. Feedback from user to innovator is therefore incomplete and fragmentary. A great deal of evidence has to accumulate before the dentists can identify undesirable characteristics of an innovation, much less decide whether they could be overcome by more skillful use or not.

This lack of user feedback also affects the shape, the physical nature, of the innovation itself. Since the intermediate users (dentists) have inadequate information themselves about end user (patient) satisfaction, they are unable to pass along to the product developers, suggestions about

improving the product from the ultimate user's point of view. Yet information from users about needed product improvement is an essential part of product development (von Hippel and Finkelstein, 1979). Lacking any direct information from end users, manufacturers naturally respond to the feedback they receive from their immediate market, the professionals. New products are therefore improved only along those dimensions which are of importance to the diffusion intermediaries. For instance, in the case of non-precious metals being developed for fusion to porcelain crowns and bridges, the first versions were much too brittle. Dentists wanted a material which could be used as easily as gold. However, in making the material easier to use, suppliers increased the nickel content and consequently the risk of allergic reactions among dental patients.

Incomplete feedback from the end user thus has two consequences: 1) The intermediaries have inadequate information on which to base the professional evaluations of innovations for which they are held responsible; 2) In developing and refining the product, manufacturers respond only to the needs and desires of the intermediary, which, as shown above, are not the same as those of the end user.

A recent case of inappropriate diffusion serves to illustrate these two consequences. An Illinois professor of periodontology (treatment of gum disease) was presented within a relatively short period of time with 38 cases of a mysterious ailment he called "black gum disease." The source for this minor epidemic was discovered only when this one periodontist tracked back the treatments all his patients had received, to isolate the common element. He found they were all experiencing serious allergic reactions to nickel or copper alloys "mostly in combination with porcelain" (Dental Laboratory Review, 1982). The individual dentists who did the original

restoration work were almost certainly unaware of the cause of their patients' problems.¹⁰ Not only, as mentioned before, are patients reluctant to return to the same dentist when they have trouble, but the allergy appeared to be a disease--which is the province of a specialist. The manufacturers are unlikely to have heard about the problem from individual patients. Therefore, they (presumably) did not know that their product, while satisfactory to the dentists, was highly unsatisfactory to the end users.

But why was such a product deficiency not caught before it was released, one might ask. The answer is that there is no repository of aggregate information fed back from users. The F.D.A., whose Dental Devices Advisory Panel has the authority to pull such products off the market, was caught unaware by the Illinois professor's discovery. "Manufacturers of non-precious alloys have not submitted their products to the F.D.A." (for testing).¹¹ Therefore even the government "watch-dog" lacks the necessary information to decide if an increase in nickel content has caused the concentration of "black gum" cases, or whether the product has always caused this reaction, but no one before was in a position to gather the scattered information necessary to make the connection between product and consequence.

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¹⁰ A number of dentists in recent focus group interviews stated their belief that alloys currently on the market do not contain nickel, yet said their lab used Rexillum III, a nickel-chromium alloy. (Decision Research Corporation, 1983).

¹¹ Dr. Gregory Singleton, in conversation with the author. March 31, 1982.

Summary and Implications

The presence of intermediaries in the diffusion process complicates both the development and dissemination of innovations. The adoption situation described in this paper differs from the usual marketing models in several critical ways. Consider the case of consumer goods. The desires and needs of the end user are reflected back to the product developer through market surveys, test markets, and, if the product makes it into actual production, in sales or lack thereof. Even if the product was developed with little input from consumers, suppliers can rarely continue to market the innovation without feedback from end users.

The diffusion of industrial products, at first glance, seems much more akin to the process modeled in this paper. Industrial buyers select technologies and components for the rest of the organization. Like the dentists described in the paper, the industrial buyer often has choice criteria which differ from those of the end-user of the technology. Moreover, his choice constrains the options open to his organizational clients.

However, the situation of the professional as innovation chooser differs from that of the industrial buyer in one very critical way: the engineers and other professionals for whom the buyer selects technology can and do influence the buying decision because they possess relevant technical knowledge about options. End users such as dental patients whose information about innovations is almost totally controlled by professionals, have much less influence over the adoption decision. In fact they are often unaware that they are recipients of an innovation. They must rely on the judgment of a professional, although that judgment is at worst biased by

self-interest and at best, often based on incomplete information. The usual recourse of a user who doubts the judgment or skill of one professional is to seek another. Therefore, intermediaries lack information feedback from users about innovations.

In the case of dental materials, medical innovations, military supplies, computer and office automation equipment, etc., innovation suppliers have two markets to satisfy: the innovation choosers and the innovation users. To the extent that those two groups of "adopters" have different or even conflicting criteria for judging the acceptability of the innovation, suppliers are unable to satisfy both. Moreover, they may not even know about some of the users' criteria. When the product is test-marketed, evaluations are solicited from the choosers. Since product success usually depends upon market-stimulated incremental adjustments, the innovation itself is shaped by the information received from these intermediate adopters--the choosers, rather than the users. Therefore, diffusion intermediaries influence the physical properties of the innovations.

Given these complications, it is inappropriate to use the usual diffusion models to analyze the dissemination of medical or other new technologies which reach the public through diffusion intermediaries. To examine only the flow of innovation from supplier to dentist or only that from dentist to patient is to ignore the need for interaction between those flows.¹² The constriction of information flows from supplier to user can lead to underadoption of beneficial innovations; constricted information flow in the opposite direction can lead to inadequate product development.

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¹² Actually, the description presented here is still over-simplified, because for some innovations (notably the non-precious metals) dental laboratories constitute yet another intermediary in the process, and one with a great deal of influence over the adoption of new materials by dentists.

Nor is the solution to these problems necessarily to bypass the intermediaries and promote innovations directly from supplier to users, for then the professionals cannot perform the important function of blocking inappropriate adoption. The diffusion of innovations through intermediaries calls for several special considerations.

First, it is important to analyze the whole system, and not to consider the chooser to be the sole target market. To do so is to invite problems in the implementation of innovation or a delayed but likely backlash from dissatisfied end users.

Secondly, the problem faced by those who would diffuse innovations in such a situation is to analyze and understand all the conflicting rewards and incentives which inspire different choice criteria between the choosers and the users. Office managers who are judged only on the speed of work delivery and not on the quality, the turnover in staff, or worker satisfaction; the army general who gains status from the sophistication but not the efficiency of the equipment his troops use, the dentist who can retain the filings from gold castings made in his laboratory as undeclared income¹³—all select technologies according to criteria which self-evidently disadvantage the end user. Intermediary choices will reflect user needs only if the users gain more power over the adoption decision or if the incentive system is changed. Obviously the course of action to take depends upon the situation. Sharing the responsibility for technology selection with users is a much more viable option for office managers than for either generals or dentists.

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¹³ The value of gold filings was epigrammatically explained to us by one informant: "I got the gold; I sell it (to the patient); I still got it (as filings) and nobody knows it (especially the IRS)!"

Finally, even if responsibility for choice cannot be shared, it should be possible to set up mechanisms for end users to report on the results of innovation back to intermediaries and to suppliers. Obviously the first step is that end-users be aware they are receiving an innovation. Beyond that, however, professionals could conceive of their position as intermediaries differently. Rather than serving as one-way conduits of selected information from supplier to user, they could assume a more active role in the two-way flow of information from users back to suppliers. Presumably, some professionals hesitate to do this now because they risk loss of prestige or valuable time. Moreover, they believe end users do not want that active involvement in innovation assessment. The research reported here suggests that end users not only want such information about innovations but they believe they are getting it. Therefore, the professional who withholds information risks losing the trust and patronage of his client. Moreover, feedback from innovation end users is essential to responsible product development.

While the case presented here is a special one, the diffusion situation described has parallels in many professional fields. Furthermore, the increasing technological sophistication of today's goods and services provides a breeding ground for ever more intermediaries. The diffusion situation presented here is therefore likely to become more rather than less common. At issue is how to manage this intermediary-dominated diffusion system so that it is responsive to user needs without denying the utility of the intermediary role.

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