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Research Article

Pharmaceutical Sciences' Manpower Supply and Internal Rate of Return

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A pharmacy student has many career options upon graduation. These options include graduate education in one of the pharmaceutical sciences and a retail pharmacy position. The attractive salaries offered by chain pharmacies play an important role in the recent graduate's career decision-making process. The purpose of this study is to provide a comparative assessment of the internal rate of return (IRR) for different pharmaceutical science career options as related to chain-store pharmacist earnings. Additionally, this study analyzes the effect of the IRR on the applicant pool size and composition for graduate study in pharmaceutical sciences. Income/age profiles were developed using public domain income data derived from salary surveys sponsored by professional associations. Based on these income/age profiles, IRRs were estimated for the pharmaceutical science disciplines, clinical pharmacy, pharmaceutics, medicinal chemistry, and pharmacy administration, and further differentiated for industry versus academic careers. The IRRs are the highest for Pharm.D.'s in academic careers (16.0%), followed by pharmaceutical scientists employed by pharmaceutical industry (8.13%). The IRR of pharmaceutical scientists in academia is lower than the return on other financial investment vehicles. Other authors have established a relationship between the IRR of a profession and a rise or decline in the applicant pool. The IRRs calculated here imply that this association can also be observed for the pharmaceutical scientist applicant pool. Low IRRs should result in a declining applicant pool. However, the last decade has shown an increase of 66% in the number of Ph.D.'s granted, while the percentage of Ph.D.'s granted to nonpharmacists or non-Americans has not increased significantly over the same time period. The supply of pharmaceutical scientists has increased, yet these increases have been outpaced by increases in demand. Improvement in support levels for graduate studies may increase the applicant pool in the pharmaceutical sciences.

KEY WORDS: internal rate of return; manpower; pharmaceutical scientists; graduate studies; graduate study enrollment; applicant pool.

INTRODUCTION

A shortage of pharmaceutical scientists has been noted in this country in industry and academia. Such a shortage usually results when demand exceeds supply. The purpose of this paper is to examine factors related to the supply of pharmaceutical scientists. Next to social and cultural factors, perceived financial reward is a strong motivator for pursuing graduate studies (1). The financial reward achieved by pursuing one investment option over another is commonly referred to as the Internal Rate of Return (IRR).

The recent pharmacy school graduate has many employment options, such as retail or hospital pharmacy, or may choose to pursue graduate education. Graduate training can be considered an investment option with an IRR. The IRR indicates the pharmaceutical scientist's reward for the time and financial investment made in graduate study.

The first objective of this study was to calculate the IRR for the different career options in the pharmaceutical sciences by discipline and length of graduate studies. The second objective of this study was to investigate the IRR as a possible contributory explanation for the shortage of pharmaceutical scientists. Available data were examined in order to substantiate or refute the impact of the IRR on the composition and size of the applicant pool for the pharmaceutical sciences. Competing hypotheses, such as a general decline in the number of Ph.D. degrees granted and an increase in the number of degrees offered to non-Americans, were also investigated.

A number of published studies have demonstrated the

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relationship between perceived and actual financial return and students' motivation to enroll in professional schools. From an economic standpoint, the decision to pursue graduate studies can be equated to an investment decision with costs, benefits, and rate of return. A positive IRR suggests that the pharmaceutical scientist can expect to earn a total lifetime premium large enough to recoup the educational and opportunity costs compared to the reference career. Consequently, it can be expected that a positive rate of return will increase the size of the applicant pool of doctoral students in the pharmaceutical sciences.

Langwell (2) has reported estimates of IRR for physicians' specialty choices stratified by sex. After adjustment for the number of hours worked by specialty group, IRRs for women were found to be much higher for medical specialty areas compared to general family practice. Pediatrics, psychiatry, and obstetrics-gynecology showed lower IRR than internal medicine or other specialty areas. For male physicians, the IRRs for specialties in surgery and obstetrics-gynecology were somewhat lower, but they were higher for other specialties. IRRs found in this study ranged from negative for female physicians in internal medicine and negative for both sexes in pediatrics to 25.3% for male physicians in radiology. The author concluded that the economic incentives for male as well as female physicians are to specialize in non-primary-care specialty areas. Economic factors are important in career decisions; it is likely that many physicians will opt for a specialty choice in a non-primary-care field.

In a study by Burstein and Cromwell (3), IRRs between 14 and 17% were found for physicians for the year 1980. Three factors contributing to this internal rate of return were identified: (1) high absolute incomes, (2) high incomes relative to other professional groups, and (3) high rates of return for medical training. IRRs for internists, surgeons, and obstetricians/gynecologists were between 10 and 15%, while a negative internal rate of return for pediatricians was observed. In calculating the IRR, medical-school tuition rates as well as medical-school grants were considered. The relative return on investment for general practitioners (12.1 and 14.5%) was higher than that for lawyers, estimated at 7.2%, but equal to that for dentists, 14.9%. The author concluded that the IRR for a career in medicine makes it a financially attractive profession.

Nask and House (4) presented a report on different issues related to dental manpower and its applicant pool. For 1978, a positive IRR of 25.3% was found for dental-school graduates in comparison with other graduates having 4 or more years of college. This study demonstrated the sensitivity of the IRR for federal scholarship and grant programs. Withdrawal of these programs caused a decrease of 1.6% points, from 25.3 to 23.7%, in the IRR. A downward trend in the IRR in dentistry was observed from 1972 on, impacting on the applicant pool size of practitioners. A strong correlation was established in this study between the size of the applicant pool and the IRR, supporting the conclusion that economic factors are important determinants of professional career choice.

The studies reviewed demonstrate a difference in IRR according to profession and professional specialization. Further, higher earnings early in the career of individuals have a positive effect on the IRR. The sensitivity of IRR to the level of financial support of the student was also noted. In addition, the literature cited supports the assumption that an association exists between IRR and applicant pool size.

METHODOLOGY

The true rate of return on an investment is the internal rate of return. It is the discount rate at which the net present value is equal to zero and can be calculated by (2)

$$\sum_{t=1}^{T} [(Y_t - Z_t)/(1 + r)^t \times P_{\text{alive}}] = 0$$

Y_t = earnings of B.S.-degree pharmacist pursuing graduate education
Z_t = earnings of B.S.-degree pharmacist practicing in a chain drug store
P_{alive} = probability that the individual will be alive in a given time interval
$t = 1$ = first year following completion of pharmacy school with B.S.
$T = 65$ = age of retirement
r = internal rate of return for graduate training

The calculation of the IRR for pharmaceutical scientists is based on a set of explicit assumptions. These assumptions include the following:

(1) completion of the baccalaureate degree in pharmacy by age 23, at which time one must consider educational or occupational alternatives for the future;
(2) a fixed length of graduate studies (5 years for Ph.D. graduates);
(3) an equal work life for all groups with retirement at age 65;
(4) zero out-of-pocket costs for continuing education to maintain license status;
(5) no educational cost, such as books and tuition for graduate studies;
(6) similar earnings/experience within groups (a similar career track within groups is assumed);
(7) $P = 1$, assuming that all groups have an equal chance of survival to 65 years of age; and
(8) IRR calculated with the earnings of the chain-drug store pharmacist as comparison; with overtime earnings not included.

Chain-store pharmacies hold a great deal of attraction for new graduates from pharmacy school. Many chains will market themselves to newly practicing pharmacists; they offer high beginning salaries with attractive benefit packages. At this point in pharmacy careers, financial incentives rate as the strongest motivating force (1). As the new graduate considers professional alternatives, the immediate financial rewards offered by chain pharmacies overshadow future personal or social gains of graduate education.

Chain stores do attract a large proportion of new pharmacy-school graduates. While 30% of practicing pharmacists are in chain stores, a substantial number of new graduates (40%) begin their careers in chain pharmacies (5,6). In a 1990 survey of pharmacy-school graduates at the University of North Carolina, 56% reported that they would be taking chain-store pharmacy positions. Of the 17% who were undecided, 5% reported that they would probably take a position with a chain. Only 4% reported that they would be pursuing postgraduate education, all in Pharm.D. training (7). Thus, chain-pharmacy salaries are employed as the reference professional group for calculation of the IRR.

Graduate studies may vary in length. A 5-year period of graduate studies was assumed, with 2 years average for the masters degree and a 3-year period for obtaining the Ph.D. degree. Some universities may not require an M.S. degree to obtain a Ph.D. degree. It has been observed that the length of time for obtaining a Ph.D. degree has increased over the last decade. The National Research Council of the National Academy of Sciences (8) reports an increase in the median length of time required to complete a doctorate, from 5.4 years in 1960 to 6.1 years in 1977 and 6.9 years in 1987. The time period for obtaining a Ph.D. degree may range from 3 years to infinity. It should be noted that each year of additional graduate training has a significant impact on the marginal rate of return.

Further, the assumption is made that retirement takes place at age 65. In industry, the mandatory retirement age is 65. It has been observed that many colleges have increased the mandatory retirement age from 65 to 70. Therefore, in academia faculty may be fully employed after 65. Pharmacists employed in the retail drug industry may opt to work after 65, full- or part-time. However, few 23 year olds will include in their consideration for future career choices the earning possibilities after the age of 65.

Continuing education (CE) costs can vary widely. Practicing in a state that does not require postgraduate CE means no additional educational cost to maintain a pharmacy license. For those who must fulfill mandatory CE requirements, many free or low-cost options are routinely offered through drug manufacturers. For chain-store pharmacists, a survey reported in *Drug Topics* (9) states that 58% are provided CE as an employee benefit. It is unlikely that the additional cost of CE will have any significant impact upon the calculation of IRR.

Out-of-pocket costs for education are not included. It is extremely difficult to estimate educational expenses for graduate-level training. Costs include tuition, student fees, and book expenses. Variation can be expected when the differences between in-state and out-of-state rates and public and private rates for tuition are considered. Additionally, tuition remission as part of the compensation of a teaching assistantship is not uncommon. Thus, the student incurs little expense. Graduate students with undergraduate pharmacy degrees are fortunate in that they can easily find pharmacy relief work to manage personal and educational expenses, although some students do finance their education through loans and incur some additional interest expense. The impact of tuition on IRR could be substantial, particularly for a high-cost private institution. The exclusion of tuition cost will most likely result in an overestimate bias. The calculated IRRs would be lower if the additional costs of tuition were added.

The assumption has also been made that each group has an equal chance of surviving to age 65. Geico, the insurance company to the American Pharmaceutical Association, employs life-tables for the general population in calculating risk for the pharmacists enrolled. Pharmacists' life expectancies are the same as those for the general public. There is no evidence that pharmaceutical scientists and chain-store pharmacists differ in their probability of survival to age 65.

Income by age in each occupation cannot be projected with certainty. An individual 23 year old in 1989 (who will be a 43 year old in 2009) will not earn the same amount as a 43-year-old pharmacist in 1989. It is common practice to construct expected age–income profiles based on what all pharmacists of all ages in a single year are presently earning. While this may not be a good estimate of future individual age-related income developments, it is the information on which career decisions are being made. For lack of better information on future incomes, this accepted approach was used in developing the age–income profiles.

It was generalized that individuals have similar earning experiences within groups. This is certainly not always true. Pharmacists employed in the retail chain-store industry may be promoted to district manager, regional manager, or buyer or have other managerial career options. However, these opportunities are limited and are included in the group experience. On average, chain-store pharmacists who were 46 years old and over in 1989 made only $600 per year more than those 36 years and under (10).

Similarly for academic faculty, we have assumed 5 years for promotion to associate professor and another 5 years for promotion to full professor, but career tracks in administrative functions are also available in universities. IRR is based on group experiences; the salaries of these individuals with advanced careers are included within the group experience.

For each alternative career choice, age–income profiles are developed based on earnings and stipends as reported in the literature. A comparison of age–income profiles at each age across different profiles is likely to find that no one profile has the highest income at every age. Thus, measures must be applied that summarize and compare these profiles in a meaningful way. The internal rate of return is a particularly useful measure because it compares one profile with another and provides a relationship between the profiles expressed in percentages.

The internal rate of return provides a summary measure that allows us to compare one age–income profile to another. It is the rate that compares the discounted present value (DPV) of the age–income profiles, weighing them by investment and income early in the career. To determine the attractiveness of an investment, a comparison is made between the IRR of that investment and the best alternative rate. The IRR is sensitive to the size of the investment base, the difference in net income between the profiles early in the career. The investment base can be considered the cost of the career with more training. If this cost is large, the rate of return may be high but not motivating. Thus, when comparing rates of return across different investments, the size of the investment base must be taken into account.

It should be noted that salary survey reports are not differentiated by degree. Therefore, the salary information does not distinguish between B.S. and Pharm.D. pharmacists practicing in chains, nor does it distinguish between Ph.D.'s in academia with and those without undergraduate pharmacy degrees. It may be that there are differences in salaries that are not captured in these figures among these groups, e.g., a Ph.D. with a pharmacy degree earns more than a Ph.D. without. The calculations assume that any such differences will not be large, particularly within each discipline.

The data are based on 1988 salary surveys published in the literature. Chain-drug store incomes were obtained from the *Drug Topics* annual survey of practicing pharmacists (10). Pharmacy faculty salaries were abstracted from the AACP 1988–1989 faculty salary survey (11), the Pharm.D. fellowship awards from *DICP, The Annuals of Pharmacotherapy,* 1988 Pharm.D. fellowship survey (12), and the pharmaceutical scientist data from *Pharmaceutical Technology* (13), which publishes the AAPS salary survey. Graduate-student stipends were estimated on an average of $9,000 per year. Individual salaries may differ; fringe benefit packages, including health and disability insurance, retirement contributions, C.E. and other reimbursements, or consultant income may differ within as well as between the career options. The reported age/income profiles were developed from average base salaries. Table AI (Appendix) displays the annual salaries on a yearly basis for the different career options in pharmacy.

RESULTS

Internal Rate of Return for Pharmacy Career Options

Table I presents the internal rate of return from post-pharmacy-degree education in pharmaceutical sciences. The highest IRR is obtained by Pharm.D.'s in academia relative to B.S. chain-drug store pharmacists (16.0%). Physicians' IRR relative to lawyers' is between 14 and 16%, while Pharm.D.'s with a 2-year fellowship have an IRR of 10.21%. This IRR is higher than for Ph.D. pharmaceutical scientists employed in industry (8.13%). Pharmaceutical scientists employed in academia have an IRR which ranges from 6.00 to 7.33%, which is lower than the return obtained on 30-year U.S. Treasury bills (8.88%, October 19, 1990). Further, the effect of postdoctoral fellowship programs is evaluated. For disciplines such as medicinal chemistry and pharmacology, where 2-year postdoctoral fellowships are common, the IRR will drop to 5.44 and 4.40%; respectively, and for pharmaceutics (although postdoctoral are less common), to 5.57%.

DISCUSSION

The relationship between the internal rate of return and the graduate-student applicant rate is one of greater social interest. For the viewpoint of society, resources should be applied where they are in greatest demand. As the premium earned by pharmaceutical scientists is calculated as a rate, it

Table I. Internal Rate of Return from Post-Pharmacy Degree Education in Pharmaceutical Science (Relative to B.S. Pharmacist in Chain Drug Store)[a]

	IRR
Pharm.D. (6 years) in academia	16.00%
Physician (relative to attorney)	14–16%
Pharm.D. (6 years with 2-year fellowship) in academia	10.21%
Ph.D. (industry)	8.13%
Ph.D. (pharmaceutics/pharmacy)	7.33%
With 2-year postdoctoral fellowship	5.57%
Ph.D. (pharmaceutical chemistry)	7.22%
With 2-year postdoctoral fellowship	5.44%
Current rate of 30 year U.S. Treasury bills[b]	8.88%
Ph.D. (pharmacy administration)	6.31%
Ph.D. (pharmacology)	6.00%
With 2-year postdoctoral fellowship	4.40%

[a] This internal rate of return shows the discount rate needed to equate the discounted percentage value for post-pharmacy degree education with the discount preset value for pharmacists in chain drug stores.
[b] October 19, 1990.

can be compared with rates of return on other investment opportunities or market rates of return. If the rate of return for graduate studies is lower relative to the rate of return on municipal bonds or other investment vehicles, the recent pharmacy-school graduate would be wise to invest the difference between a graduate stipend and his or her market value as a pharmacist in 30-year Treasury bills rathern than pursuing postgraduate education. This investment strategy would provide a higher return on investment than a career as a pharmaceutical scientist, if the student is motivated solely by financial considerations.

Theory argues that as long as this relative rate of return for graduate studies exceeds the market rate of interest, society will place resources in graduate studies. Accordingly, in developing clinical pharmacy programs, schools of pharmacy have allocated a significant amount of resources in building a cohort of clinical pharmacy practitioners. This may explain the relatively high internal rate of return for Pharm.D.'s having completed a 2-year fellowship program and pursuing an academic career.

Relatively high IRRs are found for Pharm.D. graduates working in academia compared to chain-drug store pharmacists. Pharm.D.'s employed by universities without a fellowship program show an IRR of 16.00%, comparable to that for physicians compared to attorneys. Pharm.D.'s with a 2-year fellowship program are those usually found in academic settings and show an IRR of 10.21%, higher than that for Ph.D.-trained pharmaceutical scientists. Among pharmaceutical scientists, those employed in industry show a higher IRR than those in academia.

A number of observations can be derived from this information. The Ph.D. applicant pool is clearly encroached by Pharm.D. fellowship programs. A shorter educational track, a higher graduate-school stipend, and consequently, a higher IRR are clearly advantages of a Pharm.D. career over a Ph.D. career choice. Ph.D. graduates in pharmacology and pharmacy administration would be economically better off it they had put their educational investements in 30-year Treasury bills.

There are competing hypotheses to be considered. It may be that the shortage of pharmaceutical scientists has nothing to do with the attraction of pharmacy students to the field. It may have resulted due to a general decline in the total number of Ph.D. degrees that have been granted. Actually, the total number of pharmaceutical sciences Ph.D. degrees awarded has increased and the numbers have been increasing over the last decade. While in 1978 a total of 178 Ph.D.'s were granted, in 1988, 263 Ph.D.'s were granted, an increase of 67.7%. The supply of pharmaceutical scientists measured in the number of Ph.D.'s granted actually increased over the time period 1978–1988. However, the shortage of pharmaceutical scientists may be caused because the demand for pharmaceutical scientists has increased at a steeper rate.

It may also be considered that the shortage has resulted due to an increase in the number of degrees granted to foreign nationals, if these students return to their native countries after completion of their graduate training. During the time period 1978–1988, between 24.7 and 39.9% of all Ph.D. degrees in U.S. schools of pharmacy were granted to non-Americans. This percentage remained fairly stable over time, though there was a noted jump in 1988 (See Fig. 1). In absolute numbers as well as in percentage, pharmaceutics has the largest number of non-American pharmacy Ph.D.'s (Table II). For the academic year 1987–1988, 52% of the Ph.D. graduates were non-Americans. Medicinal chemistry shows the next largest percentage of non-American Ph.D. graduates for 1987–1988, at 37.2%. Although the non-American rate of Ph.D. graduates for medicinal chemistry has been fairly stable, the percentage of non-American Ph.D. graduates for pharmaceutics has shown a steady rise for the last 10 years.

The percentage of Ph.D.'s granted to non-Americans has slightly increased over the last few years and is about 33%. The disciplines with the largest number of Ph.D.'s granted to non-Americans are pharmaceutics and medicinal chemistry. The percentage of foreign national Ph.D.'s granted in medicinal chemistry, a more established field, has stayed approximately the same. However, for pharmaceutics, a younger field, a significant increase has taken place. An increased applicant pool of foreign nationals deserves another discussion which is outside the scope of this paper. Economic factors and social factors other than those that operate for American pharmacy students play a role for this segment of the applicant pool.

Table II. Ph.D.'s Granted by Pharmacy Discipline by Year: Americans vs Non-Americans[a]

	Year					
	82–83	83–84	84–85	85–86	86–87	87–88
Pharmacy/pharmaceutics						
American	48	72	43	41	55	47
Non-American	40	32	30	39	40	51
Medicinal chemistry						
American	50	27	48	—[b]	65	59
Non-American	14	18	28	—[b]	34	35
Pharmacology						
American	41	55	49	59	50	40
Non-American	6	13	10	6	13	14
Pharmacy administration						
American	14	12	11	18	17	10
Non-American	2	3	2	1	3	4
Pharmacy practice						
American				1	2	1
Non-American				2	4	1

[a] Sources: *Am. J. Pharm. Educ.* (Summer 1984, Fall 1985, Fall 1986, Fall 1987, Fall 1988).
[b] Data not available.

It is also important to examine the number of nonpharmacists pursuing graduate training in the pharmaceutical sciences. A significant decline in the percentage of graduate students with undergraduate pharmacy degrees would be expected as a direct result of the recent significant increases in pharmacists' earnings. However, there has actually been a slight increase. See Fig. 2.

Internal rate of return has only a slight impact on the enrollment of nonpharmacists in Ph.D. programs. Nonpharmacists pursuing Ph.D. training in a pharmacy discipline are often thought to have a higher IRR because the comparison is made with what these individuals would earn as B.S. chemists. For Ph.D.'s in the biological sciences or chemistry, IRRs are higher for a pharmaceutical sciences Ph.D.

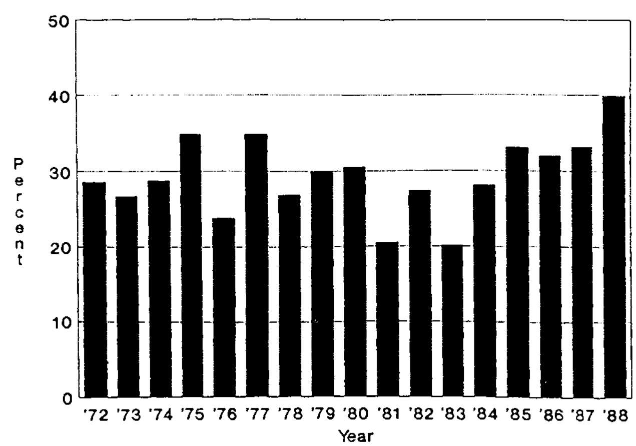

Fig. 1. Pharmaceutical sciences Ph.D. graduates: foreign graduates as percentage of total. Sources: Refs. 1 and 11.

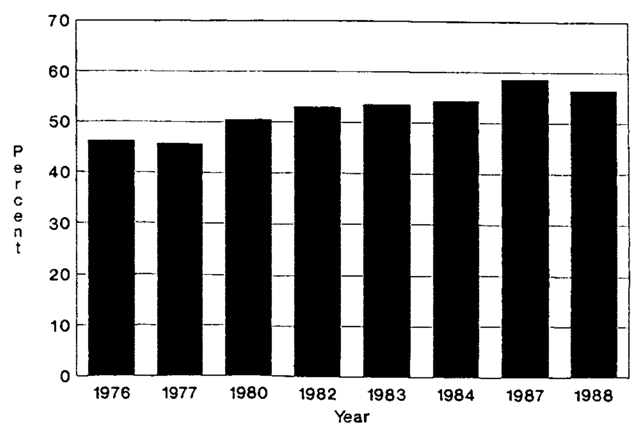

Fig. 2. Pharmacy graduate-student enrollment: previous pharmacy degree as a percentage of total. Source: Ref. 11.

while absolute starting salaries for these Ph.D.'s are also somewhat higher. Pursuing a Ph.D. degree in pharmaceutical sciences would appear to be more attractive to students in the chemical or biological sciences because of the higher IRR achieved by nonpharmacist pharmaceutical scientists. Wright reports that starting B.S. chemists' salaries for nonexperienced chemists are $21,000, while starting salaries for experienced chemists are about $29,000 (14). Similar data were provided by Babco (15). For 1987 the following starting salaries were published: B.S. in the biological sciences, $15,120; chemistry, $23,556; and pharmacy, $27,000. Lower starting salaries for majors in the biological sciences and chemistry would make them a likely applicant pool for nonpharmacist graduate training in the pharmaceutical sciences. Moreover, in the same report Babco provides median starting salaries for chemists combined for analytical, inorganic, organic, and physical chemistry disciplines with a B.S., M.S., and Ph.D. degree (15). These starting salaries were $18,600, $26,100, and $38,000, respectively, for 1986. The 1988 Survey Report on starting salaries of chemists and chemical engineering graduates provides the following median starting salaries for chemists: B.S., $21,916; M.S., $27,700; and Ph.D., $40,500 (16). Thus, while starting salaries for Bachelor of Sciences graduates for the biological sciences and chemistry are lower than comparable salaries for B.S. pharmacists, Ph.D. graduates in these fields have starting salaries that are higher than those of Ph.D. graduates in the pharmaceutical sciences. The IRR for a B.S. graduate in chemistry or chemical engineering is more attractive for a Ph.D. degree in chemistry or chemical engineering than a Ph.D. degree in the pharmaceutical sciences. Consequently, the percentage of nonpharmacist Ph.D. graduates has not increased during the last decade.

This paper has dealt with only the economic aspects of pharmacy career options. There are undoubtedly social aspects that weigh heavily in career decisions. Much of job dissatisfaction for pharmacists in retail settings stems from long hours, work schedules that interfere with family life, working conditions (i.e., inability to take breaks), lack of an intellectually stimulating environment, and lack of career options. Pharmacists are professionals with years of training who become frustrated when placed in a production-line atmosphere (17). Studies of retail pharmacist job satisfaction have shown that the need for achievement, job scope, and use of skills and abilities are inversely related to the propensity to leave an organization and to suffering job burnout (18–20).

Graduate training may not offer large and immediate financial gains but can offer flexibility, independence, personal growth, and challenge. In a survey of factors affecting the decision to pursue graduate education, Smith reports that, excluding financial motivation, students were influenced by the challenge and prestige of future jobs (1).

CONCLUSIONS

Examination of the IRR of graduate-degree education offers a plausible theory for explaining the relative shortage of pharmaceutical scientists. Although the number of Ph.D.'s granted has increased, this increase has not kept up with the increasing demand for pharmaceutical scientists. The explanation may be the relatively low IRR for pharmaceutical scientists and the availability of other career options with a higher IRR. Based on economic considerations, the investment in a Pharm.D. degree (IRR = 16.00%) or a Pharm.D. degree with a 2-year post-Pharm.D. fellowship program (IRR = 10.21%) appears to be the most financially rewarding for an academic career or a career in industry.

The impact of the IRR on the nonpharmacist segment as well as the non-American segment of the applicant pool was evaluated. It was found that the IRR of graduates in the biological and chemical sciences pursuing graduate studies in their own field was higher than that of pursuing a graduate career in pharmaceutical sciences. This may be an explanation of why the applicant pool segment of nonpharmacists has been quite stationary over time. Other motives play a role in the foreign segment of the applicant pool. It seems that foreign applicants tended to move to the relatively new field of pharmaceutics. A significant trend toward a larger number of Ph.D.'s awarded to non-Americans or nonpharmacists cannot be observed.

The calculation of the IRR focuses on dollar costs and benefits, producing a financial rate of return. Some costs and benefits, however, are nonmonetary or are difficult to measure. Thus, they cannot be included in the calculation of IRR. Therefore, this analysis is not able to represent all factors affecting the individual's decisions. It does provide important information on the size and scope of the economic factors involved in career decisions.

In order to alleviate the shortage of Ph.D.-trained pharmaceutical scientists, students must be offered a greater return on their investment. Stipends and assistantships offered to graduate students could be increased to a level comparable with fellowship salaries. Increasing the Ph.D.-student stipend to the amount offered to Pharm.D. fellows would increase the IRR for these Ph.D. scientists to a competitive level. For example, increasing the $9,000 graduate stipend (Table AI) to $19,000 increases the IRRs—medicinal chemistry to 9.23, pharmacology to 7.76, pharmaceutics to 9.29, pharmacy administration to 8.24, and industry to 10.40—for those entering the profession without postdoctoral fellowship training. Other authors have noted the impact of stipends and graduate-student support on IRR (4).

In review of the mechanics underlying the calculation of the internal rate of return, it can be observed that one attractive way to increase the internal rate of return of pharmaceutical scientists is to increase the study stipends. Stipends in the range of $17,000 to $20,000 will have a more pronounced effect on the internal rate of return than increases in income throughout the career. In addition, higher stipends may be more directly attractive to students interested in pursuing graduate studies because of the immediate measurable and direct impact they have on standards of living early in the career.

The investment necessary to become a pharmaceutical scientist is large and the graduate study period is becoming increasingly longer. Current income changes in the form of stipends will noticeably affect the applicant pool of future Ph.D. graduates. But this may not immediately alter pharmaceutical manpower trends significantly. More research into the economic and social factors related to the supply of pharmaceutical scientist manpower is clearly needed.

APPENDIX

Table AI. Age–Income Profiles in Different Pharmacy Career Options (in Thousands)[a]

						Pharmacy practice Pharm.D.				
Age	B.S.	Medicinal/pharm. chem., Ph.D., 5 yr	Pharmacology, Ph.D., 5 yr	Pharmaceutics/ pharmacy, Ph.D., 5 yr	Pharmacy administration, Ph.D., 5 yr	6 yr	6 yr + 2-yr fellowship	7 yr	7 yr + 2-yr fellowship	Industry, Ph.D.
23	40.4	9.0	9.0	9.0	9.0	0	0	0	0	9.0
24	40.4	9.0	9.0	9.0	9.0	38.3	19.1	0	0	9.0
25	40.4	9.0	9.0	9.0	9.0	39.8	19.1	38.3	19.1	9.0
26	40.4	9.0	9.0	9.0	9.0	39.8	38.3	39.8	19.2	9.0
27	40.4	9.0	9.0	9.0	9.0	39.8	39.8	39.8	38.3	9.0
28	42.1	37.4[b]	37.6[b]	39.8[b]	40.2	39.8	39.8	39.8	39.8	45.0
29	42.1	41.1[b]	40.8[b]	43.1[b]	41.4	49.2	39.8	39.8	39.8	45.0
30	42.1	41.1	40.8	43.1	41.4	49.2	39.8	49.2	39.8	45.0
31	42.1	41.1	40.8	43.1	41.4	49.2	49.2	49.2	39.8	45.0
32	42.1	41.1	40.8	43.1	41.4	49.2	49.2	49.2	49.2	45.0
33	42.1	51.6	46.8	48.8	47.8	49.2	49.2	49.2	49.2	55.0
34	42.1	51.6	46.8	48.8	47.8	63.9	49.2	49.2	49.2	55.0
35	42.1	51.6	46.8	48.8	47.8	63.9	49.2	63.9	49.2	55.0
36	42.9	51.6	46.8	48.8	47.8	63.9	63.9	63.9	49.2	55.0
37	42.9	51.6	46.8	48.8	47.8	63.9	63.9	63.9	63.9	55.0
38	42.9	72.2	63.4	66.8	66.7	63.9	63.9	63.9	63.9	68.0
39–42	42.9	72.2	63.4	66.8	66.7	69.3	63.9	63.9	63.9	68.0
43–47	42.9	66.3	60.6	68.9	66.7	69.3	69.9	69.3	69.3	68.0
48–58	42.9	72.0	71.1	76.5	66.7	69.3	69.3	69.3	69.3	75.0
59–64	42.9	72.0	71.1	76.5	66.7	69.3	69.3	69.3	69.3	79.0
IRR		7.22% (5.44%)[c]	6.00% (4.40%)[c]	7.33% (5.57%)[c]	6.31%	16.00%	10.21%	10.91%	7.75%	8.13%

[a] In computing the IRR the earnings early in each career have the most impact. Sources: Refs. 10–13.
[b] For a postdoctoral fellowship training period of 2 years these earnings are estimated as $19,000/year.
[c] IRR based on 2-year postdoctoral fellowship.

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