DOES THE NATIONAL HEALTH SERVICE CORPS IMPROVE PHYSICIAN SUPPLY IN UNDERSERVED LOCATIONS?

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INTRODUCTION

In 1970 the National Health Service Corps (NHSC or Corps) was created as part of the Emergency Health Personnel Act. The goal of this agency is to provide health personnel, most often physicians, to communities that are deemed "medically underserved." The Corps has provided an important subsidy to medical students by providing access to full scholarships covering tuition and fees in exchange for subsequent service in locations designated by the Corps.

This paper investigates two issues not examined in previous evaluations of the NHSC. First, although most studies have found that the NHSC physicians are more likely than non-enrollees to leave the community in which they initially locate, the techniques used commonly fail to recognize that the decision to enroll in the NHSC and the decision of where to locate in subsequent years may be endogenous. The results of this study are consistent with previous findings that participation in the Corps decreases the tendency to stay in the original location, even when controlling for self-selection into the program. Second, a broader measure of programmatic success is proposed. If enrollees do not remain in their initial practice locations but subsequently locate in other communities with low access to primary health care, then the program has increased access to health care in medically underserved communities. An accurate measure of the program's effectiveness should incorporate this benefit.

Data obtained from the American Medical Association [1997] allow the geographical positioning of every physician in the United States for 1981, 1986, 1991, and 1996. By comparing locational choices of NHSC enrollees with those of non-enrollees, the extent to which these federal programs decrease inequities through *subsequent* actions (that is, after the completion of the subsidy) can be determined. Two main questions are pursued in this paper:

1. To what extent does the use of the broader metric of program success proposed here—subsequent service to undeserved communities—affect the evaluation of the program's success? If the evaluation of the program takes notice of the externalities inherent in these types of programs, is a more favorable evaluation of the program obtained?

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2. To what extent does the endogeneity of program enrollment bias measures of the programmatic effect? How does the unobserved heterogeneity influence the inferences drawn from the data?

Results indicate that measuring success as subsequently practicing in an underserved community yields a positive assessment of the Corps. Furthermore, there is little evidence of endogeneity between practicing in an underserved location and the decision to enroll in the Corps. That is, it is not some unobserved preference that is affecting both, but a true programmatic effect. Nevertheless, evidence suggests that index site retention is endogenous with NHSC enrollment, and estimates of the NHSC effect on same-site retention become more negative when accounting for self-selection. Therefore, NHSC service decreases the tendency to remain in the initial practice location.

BACKGROUND

NHSC was created in 1970 to help balance geographical access to primary health care. This program works in the following manner. Medical students enroll in the program early in their medical school training and receive a full scholarship for tuition. For every year the student receives a scholarship, the student must serve one year at a location designated by the NHSC. The enrollee is presented with a list of approved practice locations from which to choose. Physicians express a preference for particular locations, and medical organizations at those locations select from those expressing an interest. After fulfilling the contractual commitment, physicians are free to enter the private workforce. In addition to the scholarship program, the Corps began offering a loan repayment option in 1987 in which physicians enroll upon graduation and the Corps repays a portion of the medical school debt for every year of service.[1]

Numerous papers have examined the determinants of physician distribution: the Newhouse, Williams, Bennett, and Schwartz (NWBS) [1982a, 1982b] studies (and the subsequent Newhouse [1990] article) combine physician distribution with standard economic location theory. They argue that location theory predicts that physicians will be less likely to locate in smaller areas due strictly to demand considerations. They argue against the conventional thinking at the time that market failures were commonplace in the physician labor supply market.

Miller, Dixon, and Fendley [1986], focusing on the West South Central states, utilize a human capital approach to find that, while there was a surplus of health care professionals in a considerable number of markets, there were also many rural areas that experienced shortages. One reconciliation of the Miller, Dixon, and Fendley [1986] results with the NWBS findings is that the quality of care, the quantity demanded, the effort per physician (in full time equivalent units, say), or some combination differs between different types of areas. The findings of Miller, Dixon, and Fendley [1986], then, support the case of market failure, not on the basis of "counts" but of "unmet need."

Numerous studies have examined physician retention. For example, Horner, Samsa, and Ricketts [1993] follow a cohort of almost 2,000 North Carolina physicians, examining how their characteristics predict whether they will move to rural or urban areas. They also investigate the hazard rate of terminating their employment. Comparisons of mean tenure suggest that hazard rates differ little between rural and urban physicians; however, controlling for physician characteristics, the propensity for leaving a community is 28 percent greater for physicians in rural communities than for physicians in urban communities. They do not, however, control for the initial selection of area type. Ricketts et al. [1996] examine migration patterns of obstetricians-gynecologists into and out of rural counties. They find that county characteristics, such as population growth, affect the relative flows into or out of the county. Furthermore, young physicians are more likely to migrate than older ones.

Pathman, Konrad, and Ricketts [1994] find that Corps physicians who are graduates of public medical schools are more likely to leave the initial placement than NHSC graduates of private schools. This effect does not exist in the non-Corps cohort. Singer et al. [1998] examine the retention of physicians at Community Health Centers. They present differences between the Corps and non-Corps physicians, such as race (Asians less likely to be Corps, African-Americans more likely) and specialty status (specialists less likely). Unfortunately, they analyze the retention of NHSC physicians separately from the retention of non-NHSC physicians, and hence are not able to measure explicitly the NHSC programmatic effect. By comparing the empirical distribution of retention rates, they (implicitly) conclude that NHSC physicians are less likely to remain in their positions than are non-enrollees. Mofidi et al. [2002] and Porterfield et al. [2003] survey NHSC alumni to analyze factors predicting index site retention.

The literature, then, in general, tends to conclude that NHSC physicians leave the community rather quickly after fulfilling their commitment. On this basis, the program seems to be supported only by a “bandage” effect, where the “bandage” justification is the increase in access while the physician is contractually obligated to serve. That is, there is no evidence that NHSC physicians continue to provide access to underserved populations after their obligation is completed, so the only impact of the Corps is the contemporaneous (during-contract) effect.

Some literature has examined the efficacy of government policy to encourage physician location into communities with low access to physicians. Bolduc, Fortin, and Fournier [1996] and Bolduc, Fortin, and Gordon [1997] examine the location choice of Quebec physicians in response to various policy options, such as reimbursement rates. They find that substantial redistribution into underserved communities is possible using market incentives. Rabinowitz et al. [2000] investigate the effect of multiple physician characteristics on the propensity to practice in a medically underserved location. They obtain a statistically significant odds ratio estimate of 2.2 for NHSC enrollment, but do not control for self-selection into the Corps. Therefore, we cannot conclude whether the Corps program increases the likelihood of practicing in underserved locations or whether Corps enrollees are *ex ante* more likely to practice in underserved communities.

The decision to enroll in any subsidy program, though, is affected by physician preferences and therefore may be endogenous to the location decision. Studies that look at the differences between program and nonprogram physicians suggest that there are substantial differences between enrollees and non-enrollees. Pathman, Konrad, and Ricketts [1992] survey physicians and present differences in the characteristics of NHSC and non-NHSC physicians. NHSC physicians are more likely to be younger and internal medicine specialists. NHSC physicians are at least 1.56 times more likely to leave in all specifications, with all estimates statistically significant. Pathman and Konrad [1996] focus on minority physicians serving in the Corps in rural areas. They find that physicians tend to be placed into counties with a high preponderance of their own race. There are some differences in the characteristics of the enrollees across minority status: minorities are less likely to be osteopaths, married, or board certified, but more likely to be pediatricians. Enrollees also have initial expectations of serving five years or less in their initial placement location. The retention profiles, though, are remarkably similar with the (unadjusted) retention rates being virtually identical.

Previous work has, in general, shown that NHSC enrollees are different from non-enrollees. This is expected; enrollment status is not randomly assigned. When physicians choose whether or not to enroll they do so based on factors unknown to the researcher. Researchers do not observe preferences for practicing in underserved communities, preferences for moving, or factors that may jointly affect the enrollment decision and locational decisions. Often, highly relevant data, such as student loan debt, marriage status, and childhood community characteristics, are unobserved. None of this previous work has directly addressed self-selection into the NHSC concurrently with retention rates, and except for the Pathman, Konrad, and Ricketts [1992] and the Rabinowitz et al. [2000] papers, none have had data sufficiently rich to enable *subsequent* location choice analysis. For example, Singer et al. [1998] analyze the groups separately: while this technique allows unbiased estimates, it does not allow measurement of the effect of the NHSC program if enrollment is endogenous. The research here explicitly controls for the selection bias while measuring the programmatic effect with a metric previously unavailable.[2]

MODEL

As stated above, there are two potential drawbacks of previous methods used to evaluate the NHSC. The first drawback is that the retention (that is, remaining in the initial practice location) measure may not give the most accurate assessment of the Corps. The second drawback is that the physician making the enrollment decision knows some of her characteristics that the researcher does not. If some of these unobservable (to the analyst) factors affect both the enrollment decision and subsequent location decisions, then the conventional methods will yield inconsistent estimates. The second drawback is an econometric one that can be corrected empirically; the first implies that the choice of outcome must be considered carefully.

The measures of success that will be estimated are the effects of NHSC enrollment on two different outcomes. The first outcome is staying in the same community over a five-year period. This outcome is one of the conventionally used retention measures. The second outcome is whether the physician subsequently locates in an underserved community. As argued above, the second measure is a more accurate assessment of the overall effect of the NHSC. Both the conventional measure (whether the physician stays) and the new broader measure (whether the physician is in an underserved community) are estimated to contrast the two measures of NHSC efficacy.

Enrollment and Subsequent Choice

Define an enrollment indicator *NHSC* as 1 if and only if the physician is observed to have enrolled in the Corps. This is the "intervention" variable of most interest in this paper. Physicians enroll in the Corps if and only if the expected utility of enrolling is greater than the utility of not enrolling:

$$NHSC_i = \begin{cases} 1 \text{ if } \mathbf{X}_i \boldsymbol{\gamma}_c + \varepsilon_i > 0 \\ 0 \text{ otherwise} \end{cases}, \tag{1}$$

where $\mathbf{X}_i$ is a vector of observed characteristics of physician i, $\boldsymbol{\gamma}_c$ is an unobserved parameter vector, and ε is an unobserved error term assumed orthogonal to all elements of $\mathbf{X}$.

The first outcome measure we are interested in is the five-year retention in the initial community. Define the dummy variable indicator

$$SAME_i = \begin{cases} 1 \text{ if physician } i \text{ is in the same location in periods } t \text{ and } t+5 \\ 0 \text{ otherwise} \end{cases}. \tag{2}$$

The variable for whether the physician remains in her first location is defined by

$$SAME_i = \begin{cases} 1 \text{ if } \mathbf{X}_\mathrm{i} \boldsymbol{\gamma}_s + \alpha_s NHSC_i + u_i > 0 \\ 0 \text{ otherwise} \end{cases}, \tag{3}$$

where $\mathbf{X}$ is a vector of physician characteristics, $\boldsymbol{\gamma}$ is an unobserved parameter vector, α_s is one of the two types of programmatic effects we will estimate, and u_i is an unobserved error term. The parameter of interest, α_s, measures the narrow definition of retention and can be used to calculate the difference between enrollees and non-enrollees in the probability of remaining in the current location.

A broader measure of programmatic success can alternatively be employed. If the program introduces physicians to a type of practice that they would not otherwise encounter and they develop a preference or specialty for this type of practice, then a NHSC enrollee who leaves the community may choose to practice in another underserved location. The experience in the previous time period will affect the utility (or information) available to the physician as she selects her subsequent location. This "broad" measure will capture the effect of the program in increasing the propensity of physicians to locate in underserved areas. If, after they complete their commitment, physicians are more likely to practice in underserved areas, then the program should be considered successful. Define

$$UNDERSERVED_i = \begin{cases} 1 \text{ if physician } i \text{ is in an underserved county} \\ 0 \text{ otherwise} \end{cases}. \tag{4}$$

The physician chooses to locate in an underserved community if the utility from doing so is greater than the utility from not doing so. In a manner identical to the derivation of the *SAME* decision, the physician chooses

(5) $$UNDERSERVED_i = \begin{cases} 1 \text{ if } \mathbf{X}_i \boldsymbol{\gamma}_b + \alpha_b NHSC_i + v_i > 0 \\ 0 \text{ otherwise} \end{cases}.$$

Similarly to above, v is unobserved. Here, α_b can be used to calculate the effect of enrolling in the Corps on the probability of locating in underserved communities in the future. The broader measure uses a new variable that indicates whether the physician is located in *any* underserved community. This new variable (*UNDERSERVED)* is the choice the physician faces when she decides in what type of community to practice. In this respect, the variable captures an alternative measure of the potential benefits of the Corps. If the physician moves to another location requiring additional health professionals, then the new location has gained a physician. It is precisely this broader measure that may affect the measure of the overall success of the NHSC.

The α parameters, naturally, are difficult to interpret since they are measured in utility. Therefore, we transform the parameter estimates to marginal effects, defined as the mean increase in estimated probability due to enrollment in the NHSC. That is, the marginal effects are

(6) $$(1/N_c) \sum_{i=1,N_c} \hat{p}_i(SAME = 1|\mathbf{X}_i, NHSC = 1) - \hat{p}_i(SAME = 1|\mathbf{X}_i, NHSC = 0),$$

where $\hat{p}_i$ is the predicted probability of physician i remaining in the same community and N_C is the number of physicians in the cohort.

Unobserved Heterogeneity

The enrollment and subsequent location decisions are not necessarily independent. It is possible, indeed quite likely, that factors influencing the enrollment propensity, such as marriage status, family wealth, age of children, and preference for working with the underserved, also impact the subsequent location choice. These factors, while observed by the physician, are not observed in these data, so such covariates cannot be controlled for. The errors ε, u, and v contain these unobserved (to the econometrician) characteristics. If the errors are incorrectly assumed to be independent, then the point estimates will be biased and inconsistent. Therefore, the estimate of the impact of NHSC enrollment will not be accurate.

One way to solve the problem of endogenous program enrollment is to use instrumental variables (IV). With this method, the researcher would need to find covariates that affect the enrollment decision without independently affecting the subsequent location choice. Given the equations of interest, however, IV is not satisfying. One would need to apply ordinary least squares to the second stage (location choice). This is not attractive for the binomial stay/move equations, where the more appropriate model is to use probit or logit regressions. Recent research into biases when one uses IV estimation with weak instruments makes the method less appealing [Bound, Jaeger, and Baker, 1995; Staiger and Stock, 1997].

We pursue an alternative and estimate the system by bivariate probit [Maddala, 1983]. Identification of the coefficient on the endogenous dummy variable is accomplished by two restrictions. Restrictions on variables in the locational decision serve as one source of identification. It is assumed (and tested) that certain variables do not affect the location decision. Hence, these exclusion restrictions identify the location equation.[3]

The second identifying restriction is the assumption that the errors are normally distributed. In contrast to IV methods, *all* the exclusion restrictions can be tested (as opposed to all but one) since functional form strictly identifies the parameters. To test for robustness, we compare the parameter estimates from the preferred model with two other estimates. First, we estimate a model in which the parameter of interest (α) is identified only by functional form. Second, we estimate a model using instrumental variable regression. If the estimates implied by the instrumental variables are similar to those of the bivariate probit, then the distributional assumptions seem reasonable. If the functional form estimates are dissimilar from the bivariate probit estimates using exclusion restrictions, then there is evidence that the instruments are valid and the estimate is identified on more than functional form.

Instruments

We have a set of four variables that we use as instruments. All are medical school characteristics. The first is an indicator for whether the medical school is public. The second is a tuition index, calculated as of 1996. It is assumed that this index reasonably proxies the tuition levels as of the time of NHSC enrollment. The third variable is the historical proportion of graduates from the medical school that declare a primary care specialty. Finally, we calculate a crude measure of medical school quality using MCAT scores and GPA of admits.

All four instruments are intuitively plausible and based in theory, a characteristic that Angrist and Krueger [2001] claim is crucial for instruments to be valid. Public schools may impart a greater sense of community service in the curriculum, so public graduates are expected to be more likely to enroll. The pecuniary value of the scholarship is proportional to the tuition, so those facing higher tuition should be more likely to enroll. A school with a higher proportion in primary care is a more fertile recruiting ground for the NHSC, so recruiting efforts may be larger at such schools, hence boosting enrollment. Finally, school quality may be an important determinant of the market value of the physician upon completion of training—graduates with higher school quality are expected to be less likely to enroll.

We test the instrument power (the null that the instruments are jointly zero in the enrollment equation) and the exclusion restrictions (the null that the instruments are jointly zero in the location equation) and report results.

DATA

The measures of programmatic success used here are the α's discussed in the previous section. These two parameters measure the increase in the probability[4] that a physician remains in the same location over a five-year interval and whether a physician practices in an underserved location in future time periods.

Data come primarily from two main sources. The American Medical Association masterfile contains data on every licensed physician in the U.S. (not just AMA members), and the data map each physician into a community. The AMA data contain physician locations for 1981, 1986, 1991, and 1996. The five-year intervals are appropriate for a number of reasons, most notably that this paper is concerned with long-term impacts. Additionally, the time commitment of an average NHSC physician is two to three years, so this allows ample time for the enrollee to leave the community after completing service.

The physician data do have some limitations. It is not clear whether the address the physician gives is for the residence or the practice. A nontrivial lag appears to exist in the updating of the addresses in the file. The AMA, however, does go to great effort to maintain the timeliness of the data. For nonmembers and update nonrespondents, the AMA obtains the address from state licensure files and other similar agencies. Therefore, even if a physician does not send the AMA information on her current location, the data contains her address and other statistics from other sources that practicing physicians must keep current.

Physicians are assigned into towns using ZIP codes. A bridge file converts ZIP codes to Federal Information Processing Standard (FIPS) place codes. FIPS codes are the standard codes (most) government agencies use to refer to geographic entities, such as states, counties, places, and townships. These place codes define the towns in the sample and determine where the physician practices. By using place codes rather than ZIP codes, some of the errors caused by changing ZIP codes can be eliminated. For example, a physician who maintains the same residence might have a ZIP code change over the period of her residence. By using the FIPS codes, the physician appears to stay in the same place, while ZIP codes would suggest she moved. The ZIP code to FIPS place technique helps to minimize the noise in the location data.

NHSC rosters define the set of enrolled physicians. Rosters indicate that 13,609 physicians (Medical Doctors and Osteopaths) enrolled in the program between 1 November 1971 (the first assignment) and 1998. Using personal identifiers, 9,671 (74 percent) of these enrollees can be matched to the AMA masterfile. This implies that enrollment status is not observed for approximately 4,000 enrollees. Because the programmatic effect of the Corps and the selection bias inherent when assuming enrollment status as exogenous are the topics of interest, it would be preferable to know the enrollment status for all physicians. The data, however, do not permit this. Because the set of unmatched individuals (the NHSC enrollees that cannot be matched to a record in the AMA masterfile) is small relative to the set of unexposed individuals (non-enrollees), this problem is ignored in this paper. This assumption might affect the estimates; estimates using models accounting for this nonmatching were qualitatively similar but had much larger standard errors. The estimates presented here, therefore, should be interpreted with caution. For a more detailed discussion on this matter and a possible approach to control for this data deficiency, see Holmes [1999].

Many indicators may be used to define "medically underserved" communities. The indicator used in this paper is the Health Professional Shortage Area (HPSA) designation. The Bureau of Primary Health Care in the Health Resources and Services Administration performs this designation. Designation can take many forms. Areas, populations, and facilities can be designated as primary care, mental health, or dental underserved areas. See Taylor et al. [1995] for a thorough discussion. The designations are based on a variety of factors, including infant mortality rate and the percent of individuals below the poverty line, but the primary basis for the designation is the population to primary care physician ratio. The ratio required for designation is 3,500:1, or 3,000:1 if the population contains high levels of infant mortality or the other risk factors. The designation used in this paper is whether the area is designated as an HPSA for primary care in 1978. In this respect, any effect of an individual physician on contemporaneous HPSA status is zero. If a physician moves to an HPSA and the new population to physician ratio drops below the threshold for designation, it would appear that the physician moved to a non-needy location, when in fact this example would be considered a success. The use of a historical measure of underservice resolves this potential problem. Designations are highly correlated over time, so the 1978 status is a good predictor of HPSA status in subsequent years.

The sample consists of all physicians who declare a primary care specialty: Family Practice, Internal Medicine, Pediatrics, Obstetrics-Gynecology, General Practice, and Unspecialized. Given the primary care mandate of the Corps, these physicians are the ones who realistically face the enrollment decision. Furthermore, comparisons between NHSC alumni and the population of all physicians not in the NHSC, which would include specialists, would not yield meaningful estimates of an NHSC effect. Secondly, given that the focus is on location decisions, the physician must have ZIP codes that can be matched to locations in their first two observations in the data. Three cohorts of physicians are selected: those with graduation dates 1977-1979, those with dates 1982-1984, and those with dates 1987-1989. A two-year cutoff before each cohort's first observation is imposed so that graduates have time to perform residency training before showing up in the data. Finally, given the use of medical school characteristics, the sample is further restricted to graduates of Association of American Medical Colleges members. This eliminates foreign medical graduates and graduates of nonmember schools. The loss of foreign medical graduates is appropriate since foreign medical graduates are not eligible for NHSC scholarships and should be excluded from the study sample.

There are multiple sample inclusion criteria. The original file of all physicians is almost one million observations. Obviously, the sample should contain only physicians who are living and whose observations can be matched across years. This brings the sample down to just over 760,000. The focus is on the location behavior of physicians immediately following medical school, so the sample is limited to graduates after 1976. This leaves 366,000, and after removing those graduating from non-U.S. medical schools (whose graduates are normally not eligible for NHSC support), the sample size is just short of 300,000 physicians. Next, the windows of eligibility described above (two to four years after graduation) and restricting to primary care physicians leave just under 100,000 physicians. Finally, since physicians are tracked over time, their location must be known in both of their first two observed years. Physicians' locations may not be known due to nonexistent ZIP codes (miskeys or ZIP codes that cannot be matched to a city). This leaves a final sample of just less than 60,000.

Summary statistics are presented in Table 1. The summary statistics for the enrollees and non-enrollees are presented separately, along with the results of a t-test that the means are equal. Note that for some variables the mean is similar for enrollees and non-enrollees, but the large sample size causes rejection of every test that the means are equal. Age at graduation is almost 28 years for both, and the primary care orientation of the medical school is nearly identical. The average "cost" (as measured by the tuition index) is much higher for enrollees then for non-enrollees. This reflects the relative attractiveness of the program for attendees of more expensive schools. Corps alumni are less likely to have attended public schools. Note that these differences, except for the proportion graduating from a public medical school, are all as hypothesized in the Instruments subsection.

TABLE 1
Summary Statistics

	Enrollees		***Non-Enrollees***		
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*T-test*
Age at Graduation	27.799	3.063	27.507	2.866	–5.22
Percent of School in Primary Care	50.539	4.197	50.333	3.966	–2.68
Instate Tuition Index	52.448	27.740	43.694	27.276	–17.26
Public Medical School Indicator	0.448	0.497	0.621	0.485	18.99
School Quality Index	–0.257	2.011	0.164	1.568	14.43
Female Indicator	0.302	0.459	0.321	0.467	2.21
Black Indicator	0.130	0.336	0.033	0.180	–15.96
Asian Indicator	0.040	0.197	0.022	0.146	–5.16
Other Race Indicator	0.030	0.170	0.044	0.205	4.43
Unknown Race Indicator	0.295	0.456	0.243	0.429	–6.27
Age at Location (1986, 1991, or 1996)	35.944	3.099	35.494	2.966	–7.95
General Practice Indicator	0.022	0.145	0.013	0.113	–3.28
Obstetrics-Gynecology Indicator	0.081	0.273	0.125	0.331	8.81
Family Practice Indicator	0.387	0.487	0.226	0.418	–18.12
Internal Medicine Indicator	0.288	0.453	0.245	0.430	–5.27
Pediatrics Indicator	0.147	0.354	0.122	0.327	–3.88
Same Town Indicator	0.305	0.461	0.355	0.479	5.94
Underserved Community Indicator	0.092	0.290	0.021	0.142	–13.79
Number of Observations	3,151		56,359		

T-test is for equality of means
"Age at Location" is the age of the physician when her location outcome is observed. For example, for the first cohort, this is age in 1986.

Table 2 presents the NHSC enrollment rates over the sample. Note that the proportion enrolling in the Corps peaks in the second period in which almost 8 percent of the sample is in the Corps. The third cohort has a very small proportion—less than 2 percent enroll in the Corps from that cohort. Because of low enrollment rates in this period, it is not expected that estimates using the third cohort will be stable.

TABLE 2
Enrollment Rates

Graduation from Medical School	Non-enrolled	Enrolled	Total
1977–1979	18,115	1,138	19,253
	94.09%	5.91%	
1982–1984	19,102	1,655	20,757
	92.03%	7.97%	
1987–1989	19,142	358	19,500
	98.16%	1.84%	
Total	56,359	3,151	59,510

Percentage is within row.

EMPIRICAL RESULTS

Enrollment

Initially, the probability that a physician will enroll in the NHSC is estimated. Estimates are presented in Table 3. Physicians who were older at graduation were more likely to enroll in the Corps, as were graduates of schools with a primary care orientation. Only in Cohort 2 does the tuition index matter; the collinearity with the public indicator is largely driving the insignificance of this variable. Graduates of private and low-quality schools are more likely to join the Corps, as are racial minorities. The indicator variable for missing race is significant in all three cohorts. Because this indicator captures the average effect of the observations for which race is missing (about 25 percent of observations), the fact that it is significantly different from zero is not alarming. All in all, however, the overall parameter estimates agree with previous findings.

TABLE 3
Enrollment Equations

Dependent Variable: NHSC Enrollment	**Cohort 1 1977–1979**	**Cohort 2 1982–1984**	**Cohort 3 1987–1989**
School Historical Proportion in Primary Care	1.392**	0.728	0.353
	(0.435)	(0.383)	(0.619)
Tuition Index	0.002	0.004**	0.003
	(0.001)	(0.001)	(0.002)
Public School Indicator	–0.264**	–0.177**	0.010
	(0.063)	(0.057)	(0.097)
School Quality Index	–0.062**	–0.051**	–0.012
	(0.009)	(0.009)	(0.014)
Age at Graduation	–0.003	0.042**	0.033**
	(0.006)	(0.004)	(0.006)
Female Indicator	–0.029	–0.091**	–0.001
	(0.035)	(0.029)	(0.045)
African-American Indicator	0.645**	0.882**	0.750**
	(0.064)	(0.054)	(0.070)
Asian Indicator	0.305**	0.535**	0.571**
	(0.105)	(0.073)	(0.094)
Other Race Indicator	0.013	0.023	–0.040
	(0.097)	(0.074)	(0.100)
Unknown Race	0.108**	0.108**	0.134*
	(0.032)	(0.030)	(0.062)
Constant	–2.202**	–3.111**	–3.457**
	(0.271)	(0.232)	(0.365)
Observations	19,253	20,757	19,500
	–4139.54	–5414.63	–1695.88

Estimated standard errors in parentheses.
* significant at the 5 percent level; ** significant at the 1 percent level.

Subsequent Period Choices

Index Site Retention (SAME). One of the questions this paper investigates is whether unobserved factors affecting the decision to enroll in the NHSC and the decision to remain in the initial practice location are correlated. We investigate the selection bias by estimating a bivariate probit model with *NHSC* and *SAME* as the dependent variables. The bivariate probit model corrects for the selection into the NHSC. As discussed in the Background section, the literature has usually concluded that NHSC physicians are less likely to remain in the index location. The conventional wisdom is that the physicians leave the town relatively quickly after fulfilling their contractual obligations.

The results in Table 4 (SAME Equations) support this assessment. Table 4 is set up as follows. The first two columns of results are for Cohort 1 (1977–1979 graduates); the second two columns are for Cohort 2 (1982–1984); and the last two are for Cohort 3 (1987–1989). Columns 1, 3, and 5 ("Probit") are the estimates when *NHSC* is assumed to be exogenous. The remaining columns ("Bivariate") are the results for the location equation when allowing the unobservable errors to be correlated.[5]

The estimated coefficients on *NHSC* (under the assumption of no correlation in the unobservables) are significantly negative for all periods (Columns 1, 3, and 5). That is, the physicians enrolling in the Corps are indeed less likely to remain in the initial location. Older physicians are more likely to stay, just as previous studies have found.

Columns 2, 4, and 6 present the bivariate probit estimates. The point estimates on the *NHSC* parameter are negative across all three cohorts and significant in the last two cohorts. Given two identical physicians, with one placed randomly in the Corps, the enrollee will be less likely to remain in the initial community than the non-enrollee.[6]

Estimated marginal effects are presented in the bottom of the table. If ρ is non-zero, the bivariate probit marginal effect is the appropriate estimate. If ρ is zero, then the simple probits are consistent and efficient and the marginal effect from that model is appropriate. The appropriate marginal effect is in bold in the table.

The estimated error correlation is positive in all three waves and significantly different from zero in the final two cohorts; unobservable characteristics that increase the probability of enrolling are correlated with unobservable characteristics that increase the probability of staying. In other words, NHSC enrollees are more likely to remain in the town than non-enrollees because of unobservable factors. This directly refutes one possible explanation of the commonly found lower retention rates for NHSC alumni. The *wanderlust* explanation—that the enrollees are more likely to move regardless of their placement, so the fact that they have shorter stays is expected—is contradicted by the findings presented here. The correlation across the equations indicates that physicians joining the Corps are *a priori* more likely to stay; it is the NHSC experience that decreases their retention.[7]

The question remains, however, whether retention is the most important outcome on which the program should be evaluated. While physician retention may indeed influence the quality of care in a community, it may be a second order consideration. A more important determination of success may be whether underserved communities have *any* physician to visit, rather than whether they have a high retention rate. While retention is an important outcome, and an important measure for evaluation of the program, it is likely more important to a particular community than to an evaluator taking a national scope of the program's success.[8]

TABLE 4
Retention Regressions

Dependent Variable: SAME	Cohort 1: 1977–79 Probit	Cohort 1: 1977–79 Bivariate	Cohort 2: 1982–84 Probit	Cohort 2: 1982–84 Bivariate	Cohort 3: 1987–89 Probit	Cohort 3: 1987–89 Bivariate
NHSC enrollee	–0.248**	–0.466	–0.272**	–0.866**	–0.270**	–1.748**
	(0.041)	(0.272)	(0.035)	(0.188)	(0.072)	(0.213)
Age	0.050**	0.049**	0.034**	0.036**	0.026**	0.028**
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Female Indicator	0.023	0.023	0.042*	0.034	0.054**	0.050**
	(0.023)	(0.023)	(0.020)	(0.020)	(0.020)	(0.019)
Af-Amer Indicator	0.029	0.061	0.002	0.147*	0.217**	0.315**
	(0.054)	(0.067)	(0.051)	(0.069)	(0.044)	(0.045)
Asian Indicator	0.079	0.085	–0.01	0.046	0.038	0.096
	(0.074)	(0.075)	(0.062)	(0.064)	(0.055)	(0.055)
Other Race Indicator	0.075	0.077	–0.043	–0.035	0.045	0.047
	(0.060)	(0.059)	(0.050)	(0.049)	(0.038)	(0.037)
Unknown Race Indicator	0.077**	0.080**	0.108**	0.120**	0.242**	0.235**
	(0.020)	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)
Constant	–2.438**	–2.423**	–1.853**	–1.935**	–1.649**	–1.709**
	(0.128)	(0.129)	(0.114)	(0.117)	(0.101)	(0.099)
Observations	19,253	19,253	20,757	20,757	19,500	19,500
Instrument Power (p-value)		0.000		0.000		0.000
Overidentification Test (p-value)		0.299		0.583		0.106
Log-Likelihood		–16,165.489		–18,267.073		–13,874.181
Test ρ = 0		0.644		8.504		17.622
p-value		0.422		0.004		0.000
Marg Effect for Bivariate Probit		–0.154		**–0.252**		**–0.340**
Marg Effect for Simple Probit		**–0.086**		–0.094		–0.092
Marg Effect off of Functional Form		–0.174		0.049		–0.335
IV Estimate		–0.156		0.892**		–5.612**

Estimated standard errors in parentheses.
* significant at the 5 percent level; ** significant at the 1 percent level.
Boldface marginal effect is the appropriate probit estimate based on the results of the test that ρ = 0.
"Marg Effect off of Functional Form" is the estimated marginal effect in a bivariate probit with all observables in both equations.
"IV Estimate" is the coefficient in a simple 2SLS linear probability model.
Specialty dummies also included in *SAME* equation.

Any Underserved Location (UNDERSERVED). *National* evaluations of the Corps should incorporate any subsequent service to underserved communities. NHSC alumni who continue to practice with underserved populations serve as a testament to the success of the program. Results using *UNDERSERVED* as the locational outcome allowing and disallowing cross-equation correlation are presented in Table 5 in a format similar to that of Table 4. Note that using the broader measure consistently yields positive assessments of the NHSC programmatic effect. Here, however, the null hypothesis that, after controlling for selection, the NHSC has no effect typically cannot be rejected.

A noteworthy result, though, is that the Corps alumni are more likely to locate in underserved communities *ex ante*. This is apparent from the estimate of the unobserved error correlation; unobservable factors increasing the probability of enrollment are positively correlated with unobservable factors increasing the probability of locating in an underserved community. The Corps is targeting those physicians with a preference for serving in needy communities. This point estimate should be interpreted with care, however, since in all three cohorts we fail to reject the null that ρ equals zero.

TABLE 5
Any Underserved Community Regressions

Dep. Var.: UNDERSERVED	**Cohort 1: 1977–79**		**Cohort 2: 1982–84**		**Cohort 3: 1987–89**	
	Probit	**Bivariate**	**Probit**	**Bivariate**	**Probit**	**Bivariate**
NHSC enrollee	0.528**	0.482	0.679**	0.745**	0.812**	0.161
	(0.059)	(0.270)	(0.053)	(0.250)	(0.106)	(0.768)
Age	0.003	0.003	0.01	0.01	0	0.002
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
Female Indicator	–0.222**	–0.222**	–0.176**	–0.174**	–0.244**	–0.244**
	(0.048)	(0.048)	(0.047)	(0.047)	(0.058)	(0.058)
Af-Amer Indicator	–0.025	–0.017	0.1	0.083	–0.061	0.022
	(0.103)	(0.114)	(0.100)	(0.125)	(0.122)	(0.171)
Asian Indicator	0.14	0.141	0.340**	0.334**	–0.321	–0.269
	(0.114)	(0.114)	(0.108)	(0.112)	(0.188)	(0.210)
Other Race Indicator	–0.458**	–0.458**	0.016	0.015	–0.24	–0.236
	(0.169)	(0.169)	(0.115)	(0.115)	(0.137)	(0.136)
Unknown Race Indicator	–0.176**	–0.175**	–0.015	–0.017	–0.142	–0.141
	(0.042)	(0.042)	(0.048)	(0.048)	(0.074)	(0.074)
Tuition Index	–0.009**	–0.009**	–0.011**	–0.011**	–0.013**	–0.013**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Public Medical School Indicator	–0.229**	–0.231**	–0.281**	–0.277**	–0.360**	–0.358**
	(0.064)	(0.065)	(0.073)	(0.073)	(0.084)	(0.083)
Constant	–1.771**	–1.767**	–2.229**	–2.214**	–1.850**	–1.932**
	(0.254)	(0.254)	(0.271)	(0.276)	(0.302)	(0.329)
Observations	19,253	19,253	20,757	20,757	19,500	19,500
Instrument Power (p-value)		0.000		0.000		0.000
Overidentification Test (p-value)		0.927		0.000		0.277
Log-Likelihood		–6,593.209		–7,306.772		–2,833.447
Test ρ = 0		0.030		0.076		0.591
p-value		0.862		0.783		0.442
Marg Effect for Bivariate Probit		0.048		0.066		0.006
Marg Effect for Simple Probit		**0.054**		**0.058**		**0.055**
Marg Effect off of Functional Form		0.036		–0.050		0.013
IV Estimate		0.098		0.068		–0.026

Estimated standard errors in parentheses.
* significant at the 5 percent level; ** significant at the 1 percent level.
Boldface marginal effect is the appropriate probit estimate based on the results of the test that ρ = 0.
"Marg Effect off of Functional Form" is the estimated marginal effect in a bivariate probit with all observables in both equations.
"IV Estimate" is the coefficient in a simple 2SLS linear probability model.
Specialty Dummies also included in BROAD equation.

Since there is no evidence of correlation between unobserved terms in the two equations, we consider the simple probit models as measures of programmatic effect. If ρ is zero, the simple probits are consistent and efficient. The inefficiency of bivariate probit is manifested in considerably larger standard errors.

Note that the set of instruments in this equation is limited to the historical proportion of graduates specializing in primary care and the quality of the school. Specification tests reveal that the remaining instruments (tuition index and public school indicator) belong in the location equation.[9]

Specification Tests and Robustness. Overall, specification tests (located at the bottom of Tables 4 and 5) validate the instruments, both as predictors of enrollment as well as poor predictors of location. The one exception is Cohort 2 for the *UNDERSERVED* outcome, in which the exclusion restrictions do not appear to be valid. When I reestimate the model for this cohort including school quality as an explanatory variable in the location equation, the exclusion restrictions are no longer rejected and the substantive conclusions are identical to the presented model. I present the model with invalid exclusion restrictions for consistency among the models. The tests of endogeneity tend to reject exogeneity for the *SAME* outcome but do not in the *UNDERSERVED* outcome. If the ρ is zero in the *UNDERSERVED* equations, the simple probit is consistent and efficient. Therefore, we consider the estimated marginal effects from the simple probits for the *UNDERSERVED* models and the estimated marginal effects from the bivariate probits for the *SAME* models.

To examine the models for robustness, both tables contain two additional estimates of the marginal effect of NHSC enrollment. First, we estimate the bivariate probit model using all available observed variables. The coefficient on *NHS*C is identified off of the functional form assumption. Secondly, we estimate a simple system of linear probability models by instrumental variables. The bivariate probit estimates are typically distinct from the functional form estimates, suggesting that the identifying variables are contributing to the *NHSC* estimate. Furthermore, the instability of IV is apparent, especially in the last two cohorts of the *SAME* equations.

CONCLUSION

There are two goals commonly advanced in support of programs such as the NHSC. One is the increase in stability of health professionals servicing a population. Increased retention fosters an atmosphere of trust. Over a period of repeated interactions, patients learn to trust their service provider and the *quality* of service is improved. A second justification is that the program creates an incentive for health professionals to locate in communities where, for one reason or another, market forces have created a condition of underserved populations. By creating circumstances that encourage physicians to practice in underserved areas, the program creates positive externalities. A narrow evaluation based on the experiences of the town receiving the subsidy would not accurately capture the complete national effect of the program. That is, a measure capturing the experience of only the targeted community understates the true social benefit of the program. In this manner, the conventionally used measure for NHSC "success," retention in the same community, does not capture the complete effect of the program.

The results of this study suggest that enrollment in the Corps may decrease the probability of remaining in the initial location but increase the probability of locating in underserved communities. This indicates that the choice of an outcome measure may be immensely important in evaluating the Corps. The narrow, conventionally used measure resulted in an unfavorable assessment of the Corps. The broader measure employed here offers a favorable assessment.

Opportunities for future research abound. Clearly, the placement of these programs is not random. Towns that have less success attracting, and keeping, physicians are stronger candidates for being awarded a program. The endogenous nature of the program placement will lead to biased estimates. Subsequent work should incorporate both the endogenous program placement and the self-selection into the program. Finally, more federal programs can be added to the evaluation. For example, one could explicitly include Community Health Center presence as an additional program affecting physician supply in the community. Perhaps there are gains to having greater infrastructure to support the physician. This may imply possible policies that increase the NHSC effect. Definitive conclusions regarding the cost-effectiveness of this program are unattainable. Without knowledge of relative impacts of other programs, the success of the program cannot be critically evaluated. Future research in this field should examine the cost of the program and the benefits from continued expansion in a true cost-benefit analysis.

APPENDIX

Contamination Effects

The contamination of the *NHSC* dummy variable indicator is potentially a large problem. This section explores the potential effect of this contamination. Heckman and Robb [1985] develop appropriate methods for regression-based estimators in the presence of contamination, but maximum likelihood models are used here. Instead, evidence from a simulation is presented.

In order to ascertain the potential impact on the estimates, the following experiment is performed.

1. Load the original data.
2. Randomly recode a proportion of the nonmatches (*NHSC = 0)* to be enrollees (*NHSC = 1*), where the estimated proportions come from Holmes [1999].
3. Estimate the models, saving the marginal effects.
4. Repeat.

This experiment is repeated 100 times. In each iteration, the bootstrapped sample represents one possible state of the world, with (an estimate of) the actual proportion of NHSC enrollees. Results for the marginal effects are presented in Table A-1 below.

TABLE A-1
Bootstrapped Marginal Effects

Cohort	Dependent Variable	Method	Ignoring Contamination	Bootstrapped Mean	5th percentile	95th percentile
1977–1979	*SAME*	*Probit*	–0.086	–0.064	–0.075	–0.053
1977–1979	*SAME*	*BVP*	–0.154	–0.207	–0.250	–0.159
1977–1979	*UNDERSERVED*	*Probit*	0.054	0.041	0.037	0.045
1977–1979	*UNDERSERVED*	*BVP*	0.048	0.028	0.015	0.039
1982–1984	*SAME*	*Probit*	–0.094	–0.075	–0.083	–0.067
1982–1984	*SAME*	*BVP*	–0.252	–0.294	–0.314	–0.272
1982–1984	*UNDERSERVED*	*Probit*	0.058	0.046	0.044	0.048
1982–1984	*UNDERSERVED*	*BVP*	0.066	0.088	0.074	0.104
1987–1989	*SAME*	*Probit*	–0.092	–0.064	–0.079	–0.045
1987–1989	*SAME*	*BVP*	–0.340	–0.332	–0.347	–0.317
1987–1989	*UNDERSERVED*	*Probit*	0.055	0.040	0.036	0.044
1987–1989	*UNDERSERVED*	*BVP*	0.006	0.053	–0.001	0.218

100 replications. Percentiles defined empirically.
See text for definition of bootstrap simulations.

In general, the bivariate probit models generate comparable estimates on the marginal effects. In five of the six bivariate models, the marginal effect obtained by ignoring the contamination is between the 5th and 95th percentiles of the bootstrapped marginal effects. The probits perform less well, due mostly to the smaller range of the estimates in the probit models. In all 12 models, the marginal effects are qualitatively similar. Although quantitative use of the marginal effects, for example in policy simulations, would be questionable based on the results presented in Table A-1, the underlying findings of this paper seem robust to this contamination.

NOTES

Partial support for this research has been provided by the Agency for Healthcare Research and Quality through a National Research Service Award Predoctoral Traineeship sponsored by the Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, #T32-HS00032-10. In addition, data were provided to the author from the Evaluation of the Effectiveness of the National Health Service Corps, HRSA Contract number #240-95-0038, conducted by the University of North Carolina at Chapel Hill and Mathematica Policy Research. I thank Tom Mroz, Bob Konrad, three anonymous referees, and workshop participants at the University of North Carolina-Chapel Hill, the Congressional Budget Office, the Agency for Healthcare Research and Quality, and East Carolina University for useful comments. This work reflects the opinion of the author and not necessarily the opinion of the Health Resources and Services Administration. The usual caveat applies.

1. The loan repayment program was only available for two years of the sample. Due to the small number of loan repayment enrollees, we treat all NHSC enrollees equally independent of the exact nature of their service.
2. Two recent exceptions are Mofidi et al. [2002] and Porterfield et al. [2003], who use survey data to employ a version of the broader metric considered here. The first examines dentists, a small proportion of the NHSC, and the second examines only NHSC alumni.
3. For expository purposes, we refer to variables included in the NHSC equation but excluded from the location decision as "instruments."

4. Of course, the α's do not *technically* measure the increase in probability—they measure the change in the index that is mapped into a probability.
5. Enrollment equation estimates are little different from those presented in Table 3, save being a bit more precise.
6. One simple explanation is that "no-compete" clauses that exist in some contracts force NHSC physicians to move away after completing the contractual obligation.
7. Other specifications were investigated as well. The general results hold across specifications.
8. This is not to say that a low retention rate has no negative impacts on the NHSC program. A high turnover rate does impose costs on the Corps, but there may be other important outputs to consider.
9. Using only school quality and the historical proportion of graduates in primary care as instruments for the *SAME* outcome yielded results similar in all respects to those presented in Table 4. This has the spirit of a Mroz [1987] test—removing potentially problematic instruments does not substantially alter the results, supporting (at least subjectively) the validity of the instruments.

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