A Model to Determine Workforce Needs for Endocrinologists in the United States Until 2020*

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The objective of this study was to define the workforce needs for the specialty of Endocrinology, Diabetes, and Metabolism in the United States between 1999 and 2020. An interactive model of factors likely to influence the balance between the supply and demand of endocrinologists during the next 20 years was constructed. The model used data from a wide range of sources and was developed under the guidance of a panel of experts derived from sponsoring organizations of endocrinologists. We determined current and projected numbers and demographics of endocrinologists in the U.S. workforce and the anticipated balance between supply and demand from 1999 to 2020. There were 3,623 adult endocrinologists in the workforce in 1999, of which 2,389 (66%) were in office-based practice. Their median age was 49 years. Both total office visits and services performed by endocrinologists (particularly for diabetes) increased substantially during the 1990s. Waiting time for an initial appointment is presently longer for endocrinologists than for other physicians. Compared with a balanced, largely closed-staff health maintenance organization, the current national supply of endocrinologists is estimated to be 12% lower than demand. The number of endocrinologists entering the market has continuously fallen over the previous 5 years, from 200 in 1995 to 171 in 1999. Even if this downward trend were abruptly stopped, the model predicts that demand will exceed supply from now until 2020. While this gap narrows from 2000 to 2008 due to projected growth of managed care, it widens thereafter due to the aging of both the population and the endocrine workforce. Inclusion of other factors such as projected real income growth and increased prevalence of age-related endocrine disorders (e.g., diabetes and osteoporosis) further accentuates the deficit. If the number of endocrinologists entering the workforce remains at 1999 levels, demand will continue to exceed supply from now through 2020 for adult endocrinologists, and the gap will widen progressively from 2010 onward. The present analysis indicates that the number of endocrinologists entering the workforce will not be sufficient to meet future demand. These data suggest that steps should be taken to stop the ongoing decline in the number of endocrinologists in training and consideration should be given to actions designed to increase the number of endocrinologists in practice in the years ahead.

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Abbreviations: AMA, American Medical Association; BMAD, Medicare Part B Beneficiary Annual Claims Data; COGME, Council on Graduate Medical Education; DEXA, dual energy X-ray absorptiometry; GMENAC, Graduate Medical Education National Advisory Committee; HMO, Health Maintenance Organization; IMG, International Medical School Graduate; NAMCS, National Ambulatory Medical Care Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Studies of the physician workforce in the U.S. can be traced back to the late 1960s, when concern developed that the supply of physicians would be inadequate to meet the nation's future needs. The Graduate Medical Education National Advisory Committee (GMENAC) was founded in 1976 by the U.S. Department of Health Education and Welfare (now Health and Human Services) in part to address this concern. The committee used "expert opinion" to estimate the projected need for physicians in the year 1990. The concept of centralized planning introduced by GMENAC was strengthened by the establishment of the Council on Graduate Medical Education (COGME) in 1986. COGME shifted its deliberations from the adequacy of the physician workforce to the question of whether the balance between the number of generalists and specialists was appropriate. This concern was heightened by a report by Weiner (1) in 1994 that a substantial excess of specialists would exist by the year 2000. This estimate used the then-novel "benchmark" approach that was based on staffing patterns of "staff-model" health maintenance organizations (HMOs).

Centralized planning of residency positions became an important element in the Clinton administration's proposal for health care reform, the Health Security Act of 1993. The failure of Congress to pass this bill has resulted in a shift in the focus of workforce studies away from centralized planning toward analyses of the effect of market factors such as managed care on the demand for service.

Since the demographics of both the nation and its workforce have changed dramatically during the last several years and since an analysis of the adequacy of the endocrine workforce has not previously been conducted, a consortium of endocrine societies, including The Endocrine Society, the American Association of Clinical Endocrinologists, the American Diabetes Association, the Association of Program Directors in Endocrinology and Metabolism, and the American Thyroid Association, commissioned the Lewin Group to conduct an endocrine work-

force study. This study sought to determine *1*) the number and demographic characteristics of endocrinologists presently in the workforce; *2*) the number of fellows currently in endocrine training programs; *3*) the effect of age and retirement rates on the size of the workforce; and *4*) the factors that influence the demand for endocrinologists. We then used this information to develop a model designed to project endocrine workforce needs over the next 20 years. The key assumptions of the model were identified and the sensitivity of the model to these assumptions was tested. The model was made interactive to facilitate testing of these assumptions by other interested parties and to permit ongoing evaluation of the accuracy of the model as updated data become available in the years ahead.

Defining the Current Workforce

The American Board of Internal Medicine began certifying endocrinologists in 1972. For the purposes of the present study, an endocrinologist was defined as an MD or DO (Doctor of Osteopathy) who meets the self-reported criteria developed by the American Medical Association (AMA) (2). The AMA records include all U.S. physicians, not only those who are members of the AMA. According to 1999 AMA records, 4,133 physicians identified themselves as endocrinologists for adult patients. Of these, 3,623 were board-certified or had completed graduate medical training and indicated their major professional activity as office-based practice (66%), full-time hospital staff (10%), research (13%), teaching (4%), administration (4%), or "other" (3%). Some physicians who identified themselves as endocrinologists who were not board-certified either were trained before the institution of board-certification or, as is any physician's prerogative, call themselves endocrinologists without completion of subspecialty training.

In 1999, the workforce was 70% male (3). The median age of endocrinologists was 49 years, compared with 44 years for all nonendocrine physicians (4). The older age of the endocrinologists is due, at least in part, to the fact that duration of training for a subspecialist is longer than that for a nonsubspecialist. There were virtually no endocrinologists under age 30 years.

Supply and Demand of the Endocrinology Workforce

Published data regarding supply and demand statistics are limited for all physician specialties, including endocrinology. Therefore, our analysis of supply and demand was conducted using several independent methods and data sources. In doing so, we assumed that concordance among the various approaches would support the correctness of the findings, whereas inconsistency would suggest that the conclusion of any individual approach should be viewed with caution.

Factors Influencing Supply

Trends in residencies and fellowships

One of the most important factors affecting the supply of endocrinologists is the number of individuals per year who complete an endocrinology fellowship. This depends on the number of fellowship positions, the percentage of positions filled, and the time spent in training. According to the Accreditation Council for Graduate Medical Education, in 1999 there were 457 adult endocrinology fellowship positions in 132 programs. According to the National Study of Graduate Medical Education in Internal Medicine, there were 393 fellows enrolled in endocrine training programs in 1998–1999 with a "fill rate" of 86% (3). Of note, the total number of fellows enrolled in endocrine training programs declined from 459 in 1995 to 393 by 1999 (3). This 14.4% decline was similar to the overall decline of 13.2% in all internal medicine subspecialty training programs with only nephrology (+0.9%) and geriatrics (+74.6%) bucking the trend. This decrease also follows a trend in the overall subspecialization rate, which declined from 65.2% in 1978 to 58.9% in 1992 and 39.0% in 1997.

The duration of endocrine training programs varied from 2 to 3 years. It was estimated that ~171 fellows in adult endocrinology complete their training each year. This number correlates well with the number of individuals who take the endocrinology board examination. In 1999, 169 candidates took the adult endocrinology, diabetes, and metabolism boards as first-time candidates.

A portion of the fellows who complete an endocrine training program never practice in the U.S. In 2000, international medical school graduates (IMGs) constituted 57% of fellows in adult endocrinology programs. This was unchanged from the percentage of IMG fellows in 1994, although there was a substantial increase in all internal medicine residency programs (from 15.2 to 20.6%) and in some other internal medicine subspecialties (e.g., cardiology, from 37 to 41%; gastroenterology, from 28 to 46%; hematology-oncology, from 48 to 60%). Only nephrology experienced a decline (66 to 46%) (3). While there are no firm data as to the number of U.S.-trained IMGs who ultimately practice in the U.S., based on discussions with experts at the Bureau of Health Professions, we estimate that ~80% of IMGs do so and thus substantially contribute to the supply of endocrinologists. This may change if fewer waivers are given to J-1 visa holders to work in medically underserved areas (under an H1-B visa status), thus requiring them to return to their country of origin before seeking employment in the U.S. The number of H1-B visas is capped at 195,000 for all workers for fiscal years 2001–2003 and reverts back to its original cap of 65,000 per year in 2004. Furthermore, recommendation 7 of the Fourteenth Report of the Council on Graduate Medical Education (5) stated that national policies and administrative procedures related to physicians with temporary visas should be revised consistent with the original purpose of these visas. COGME also recommended that the length of time that J-1 visa physicians return to their originating countries be increased from 2 to 5 years.

Retirement rates

The age and rate at which endocrinologists withdraw from practice affects the supply of endocrinologists. Retirement patterns for all physicians, as estimated in the late 1980s by Roehrig and Janayan (C.S. Roehrig, A.M. Janayan: "Physician Separation Rate Estimation," unpublished report to the Health Resources and Services Administration, Vector Research, 4 September 1986), indicate that retirement rates begin to increase when physicians are in their late forties, followed by a more dramatic climb that rises to 8% per year by age 60 years. In the absence of additional endocrinologists entering the marketplace, an 8% annual retirement rate would reduce the number of practicing endocrinologists by 50% within 8 years. In addition, mortality rates are important beyond age 60 years. Retirement and mortality combined are expected to reduce an age-50 cohort of practicing

physicians by about 80% through age 75 years.

Factors Influencing Demand

Use of the Medicare Part B Beneficiary Annual Claims Data (BMAD) file to estimate current demand

Statistics from the Medicare program provide nearly complete claims data for a large group of individuals over age 65 years that is expected to grow from 14.2% of the population in 2000 to 18.6% by 2020. The Medicare Part B Beneficiary Annual Claims Data (BMAD) file (6), which includes data regarding reimbursement for physician office visits, procedures, and other outpatient services, indicates that total part B reimbursements declined by 1.5% across all part B providers between 1995 and 1998. In contrast, reimbursement increased by 0.4% for endocrinologists over the same interval. Office visits were the most important reimbursement service, representing 29.4% of all part B reimbursements to endocrinologists in 1995 and 32.8% in 1998. Over this interval, the total dollar volume for endocrinologists grew by almost 24%. A similar pattern was observed for claims volume. The endocrinologist service that increased the most during this period was "dual energy X-ray study" (dual energy X-ray absorptiometry, or DEXA), which grew from $1.1 million to $4.5 million. Although this may have been due in part to the Centers for Medicare and Medicaid Services' (formerly the Health Care Financing Administration) recognition of the procedure for billing purposes, it also suggests that osteoporosis is likely to result in a growth in demand for endocrinologists' services as the population ages.

The National Ambulatory Medical Care Survey (NAMCS) to estimate current demand

The National Ambulatory Medical Care Survey (NAMCS) captures office visits by provider type and the reason for the visits. The NAMCS data are more general than the BMAD files; they include all patients, not just those who are eligible for Medicare (7). They also provide weights that permit generalization to the U.S. population. The relatively low number of endocrinologists in the survey (13 in 1993–1995 and 12 in 1996–1998) is a weakness of this data source. However, since it is a random sample, the results for endocrinologists presumably are "unbiased." In addition, it represents a similar percentage sampling of office-based endocrinologists (0.32%) as of internists (0.54%). To minimize variability due to sample size, the results of two 3-year periods, 1993–1995 and 1996–1998, were compared. The year 1998 is the latest for which data are available.

The NAMCS data indicate that office visits to endocrinologists increased substantially during the last decade. There were more than twice as many office visits to endocrinologists in 1996–1998 as in 1993–1995. This trend is consistent with Medicare data showing a 25% increase in office visits to endocrinologists between 1995 and 1998. Tabulation of the number of office visits for endocrinologists and other major specialties that provide similar services (i.e., internal medicine, general practice, family practice) indicates that there was a 5% increase in endocrinologists' office visits associated with diabetes, while there was a decrease of 6–7% for general internists and family practitioners. The share of visits for "diseases of the thyroid" increased for family and general practitioners by 14%, but decreased for endocrinologists by 2%.

Waiting time for initial visit to estimate current demand

To assess waiting time for an initial visit with an endocrinologist, a survey of 2,087 physician members of The Endocrine Society was conducted in February of 2000. Four hundred eighty-two endocrinologists responded (23.1%). The average waiting time for an initial nonurgent visit with an adult endocrinologist was 37 days. In comparison, the average waiting time for an initial visit with "all physicians" (excluding radiologists, psychiatrists, pathologists, and anesthesiologists) was 10 days for general internal medicine and 17 days for neurologists and dermatologists (6). Thus, the mean waiting time for an appointment with an endocrinologist was greater than that for "all physicians," general internists, neurologists, and dermatologists, implying a greater demand for endocrinologists.

An HMO "benchmark" to estimate current demand

Another method of estimating physician demand is to "benchmark" the ratio of specialists in an HMO to the population served by the HMO to the ratio present in the general population (8). This method was used by Weiner (1) to estimate demand under health care reform and by Goodman et al. (8) for HMO, managed care, fee-for-service, and "balanced" physician supply conditions.

We chose Kaiser Permanente's Mid-Atlantic States HMO as a benchmark of demand for practicing endocrinologists. Kaiser is regarded as an HMO that has achieved a "reasonable" balance between cost-containment and quality of health care. If so, it presumably provides a reasonable estimate of demand for endocrinologists under an integrated managed care system. Kaiser Permanente's Mid-Atlantic States plan has 555,775 members and lists five adult endocrinologists, giving a ratio of 0.9 per 100,000 (http://www.kaiserpermanente.org/locations/midatlantic/, September 2000). This value is very similar to the 0.8 per 100,000 estimated by Weiner (1) in 1992 for a number of HMOs (including many that were believed to be "aggressively managed").

Since the demographics of the Kaiser population differ from the general population with respect to age (e.g., U.S. population over 65 years of age is 12%, whereas in the HMO population it is 1%), we adjusted the data by constructing an index of utilization using the formula

$$I = \frac{\sum_i W_{US,i} U_{US,i}}{\sum_i W_{HMO,i} U_{HMO,i}}$$

where W represents the population proportion in each of the three age groups (i) and U is utilization, per 1,000, in the respective age group.

The calculated utilization index was 1.12, indicating that when adjusted for age, health care utilization for the entire U.S. adult population is 12% greater than that observed in the Kaiser Permanente system. Accordingly, the U.S. population would require about 1.0067 adult endocrinologists per 100,000 of population to provide health care services equivalent to those provided by the Kaiser Permanente system. This is equivalent to 2,705 office-based adult endocrinologists, or 12.2% more than were in practice in 1999.

Potential effects of population dynamics on demand

Aging of the population will impact future demand for health care services. In 2000, there were 39.1 million people age 65 years or over (14.2% of the total population). The number over age 65 years will

increase to 45.5 million, or 15.2% of the total population, by 2010 and to 60.5 million, or 18.6% of the population, by 2020.

Both the incidence and prevalence of diabetes increase with age. The prevalence of diabetes in the population over the age of 70 years is in excess of 10% (9). Other endocrine-related diseases also increase with age. The prevalences of osteoporosis and hypothyroidism exceed 25 and 17%, respectively, for women age 65 years or older (9,10). In addition, there has been an alarming increase in the incidence of type 2 diabetes among children, attributed to obesity, sedentary lifestyle, and diet. This, combined with the progressive gain in weight of American adolescents, presages a still greater increase in the prevalence of this disease in adults (11). Thus, demand for endocrine services is likely to increase as the population ages.

Effects of managed care, insurance, and household income on demand

Changes in managed care, insurance coverage, and household income all have the potential to alter the demand for subspecialty care. In an effort to estimate the effect of these factors on the demand for endocrinologists' services, we developed a model using data on the geographic distribution of endocrinologists across the U.S. The hypothesis underlying this approach is that physicians will migrate into areas where demand is relatively strong and away from areas where demand is relatively weak. If so, the number of physicians in a given area can serve as a proxy for demand for service in that area and therefore provide insight into the effects of factors such as level of insurance coverage, managed care penetration, and household income on demand for the services of endocrinologists.

To develop the model, we used data from the July 1999 Interstudy Competitive Edge Part III Report (12) and the 1999 Area Resource File (13) in combination with the following equation: $E^d/pop = f(I,UI,MC,PC,OS)$, where the ratio of endocrinologists to the population (E^d), interpreted as "demand," is a function of per capita income (I) in the region, the percentage uninsured (UI), the managed care (HMO) penetration rate (MC), the number of primary care physicians in the area (PC), and the number of selected other specialties in the area (OS). The dependent variable is the ratio of endocrinologists to population by Metropolitan Statistical Area.

Table 1—*Factors affecting demand for adult endocrinologists*

	Coefficient	*P*	Mean	Elasticity§
Intercept	−1.1821	0.04		
HMO penetration for Medicare population*	1.0925	0.05	0.1175	0.0965
HMO penetration for non-Medicare population*	−1.5194	0.0005	0.2673	−0.3053
% Uninsured non-Medicare population*	−0.1587	0.90	0.1874	−0.0224
Median household income†	0.00000849	0.50	35,433.77	0.2263
General practitioners per 100K population‡	0.0099	0.02	36.4763	0.2711
General internal medicine per 100K population‡	0.0613	0.0001	35.2245	1.6225

Mean number of adult endocrinologists per 100,000 population = 1.5663; $R^2 = 0.76$; adjusted $R^2 = 0.75$. *The managed care data used in this model were derived from the Interstudy Competitive Edge Part III report from July 1999 (12). The data included estimates of total population, total HMO enrollment, HMO and Medicaid enrollment, non-HMO and Medicaid enrollment, and uninsured population for 306 Metropolitan Statistical Areas (MSAs). †Population and median household income are from the 1996 census estimates, updated through the current population survey, as they appeared in the 1999 Area Resource File (ARF), produced by the Health Resources and Services Administration (13). Data in the ARF are listed at the FIPS (county) level but are labeled according to MSA as well. Our MSA-level figures for median household income were calculated by taking an average of incomes for all counties in a given MSA, weighted by the 1996 Census population of that MSA. ‡For general practitioners, general internists, and urologists, we used estimates from the 1995 and 1997 AMA Physician Characteristics and Distribution publications as they appeared in the 1999 ARF. §Elasticity is a measure that summarizes how one factor responds to a change in another factor. An elasticity of −0.3 for managed care penetration with respect to the demand for physician services, for example, means that a 10% increase in the managed care penetration rate results in a 3% decline in the demand for physician services.

As evident in Table 1, this analysis indicates that the effect of the managed care penetration rate for the non-Medicare population is negative and statistically significant. The "elasticity" of −0.3053 indicates that a 10% increase in the managed care penetration rate is associated with a 3% decline in demand for endocrinologists. Of interest, the managed care penetration rate for the Medicare population has a positive effect on demand for overall medical services. A 10% increase in the Medicare managed care rate is associated with a 1% increase in overall demand for medical services. This counterintuitive result may be due to the relatively low rates of managed care in the Medicare age group and the fact that high-demand areas have tended to come under managed care first. As expected, the proportion of the population that is uninsured has a negative effect on demand. Though the estimate is not statistically significant, a 10% increase in the uninsured rate is associated with a 0.2% decrease in demand. Household income has a positive effect on demand: a 10% increase in household income is associated with a 2.7% increase in demand, consistent with the previous report by Newhouse et al. (14). Increasing numbers of general practice physicians and internal medicine physicians result in an increase in the demand for endocrinologists.

Projections of Supply and Demand in a Workforce Model

Having identified factors that influence supply and demand, we used these data to develop an Endocrinologist Workforce Model and to project the balance between supply and demand over the next 20 years. Since the model is interactive, it permits a "sensitivity analysis" of factors that can affect the workforce.

Model description

The model consists of two major equations: a supply equation and a demand equation. The supply projection begins with the historical, inherited workforce, defined as the number of endocrinologists by age. One might think of this as an "inventory" of practicing endocrinologists. This inventory is then "aged" using estimates of mortality and retirement rates (C.S. Roehrig, A.M. Janayan: "Physician Separation Rate Estimation," unpublished report to the Health Resources and

Services Administration, Vector Research, 4 September 1986). New entrants to the profession are included as they enter from fellowship programs. New entrants are modeled as a function of fellowship positions, the fill-rate of fellowship positions, and the proportion of IMGs among the new entrants.

The basic equation for the supply model is

$$I_t = \sum_{a=33}^{70} I_{a,t-1}(1 - m_{a,t-1})(1 - r_{a,t-1}) + E_{33,t}$$

where I_t is the number of endocrinologists in period t; $I_{a,t-1}$ is the number of endocrinologists who were a years old in period t–1; and $m_{a,t-1}$ and $r_{a,t-1}$ are the respective mortality and retirement rates for endocrinologists who were age a in period t–1. $E_{33,t}$ is the number of new endocrinologists entering practice from fellowship positions in period t.

The demand model is driven by characteristics of the population. It then projects the demand for endocrinologists per population—a physician-to-population ratio. Factors affecting demand that are included in the model are managed care penetration rate, real per capita income of the population, growth in the number of competing providers per population, and changes in the incidence of diseases, such as diabetes.

The basic equations for the demand model are of the form

$$P_t = P_{t-1}(1 + \varepsilon_{mc}(\Delta MC_{t-1,t}/MC_{t-1}) + \varepsilon_{cp}(\Delta CP_{t-1,t}/CP_{t-1}) + \varepsilon_{pr}(\Delta PR_{t-1,t}/PR_{t-1}) + \ldots +)$$

where P_t is the endocrinologist-to-population ratio at period t; $\Delta MC_{t-1,t}/MC_{t-1}$ is the change in the managed care penetration rate between period t–1 and t as a proportion of the initial period's rate; and $\Delta CP_{t-1,t}/CP_{t-1}$ is the proportionate change in the supply of competing providers per population between period t–1 and t. Similarly, PR is per capita real income. Depending on the scenario being considered, other variables, such as the change in the percentage of the insured population or change in the prevalence of diabetes, are included in the prediction equation. The variables ε_{mc}, ε_{cp}, and ε_{pr}, and so forth are behavioral parameters relating the proportionate change in managed care penetration ratio, supply of competing providers, per capita real income, and so forth to a proportionate change in demand for endocrinologists as measured by the endocrinologist-to-population ratio. These parameters are called elasticities. That is, if ε_{mc} were equal to –0.5, then a 0.1 proportionate increase in the managed care penetration ratio (a 10% increase in the managed care penetration rate), other things being equal, would result in a 0.05 proportionate decline in the demand for endocrinologists, as measured by the endocrinologist-to-population ratio (a 5% decline in the endocrinologist-to-population ratio).

The parameter estimates used in the various scenarios are derived from several sources. The managed care effects, the per capita real income effects, and the effects of insurance on demand, as measured by the elasticities, are from the econometric results presented above. In addition, the literature provides estimates of the effect of per capita real income on demand for physician services that were also considered. The effect of changes in the prevalence of diabetes on the demand for endocrinologists is based on an analysis of the current share of diabetes patients treated by endocrinologists and the demand that they place on physicians' time. Note that if there are no changes over time in the factors affecting demand, that factor does not affect changes in future demand. Default parameters (elasticities) are specified in the model. However, since the model was created as a spreadsheet, the user may change these parameters for any given analysis to test the sensitivity of the model to a given assumption and to update the model predictions as additional data become available.

Model predictions

Table 2 lists a series of scenarios that incorporate factors that we believe provide a progressively more accurate estimate of the future balance between supply and demand. The projected supply and demand curves for each scenario are shown in Fig. 1.

We believe that scenario 6 is the most realistic of the scenarios, since it includes an estimate of the impact of the increase in the number of people who have diabetes, the major disease treated by endocrinologists. However, we chose scenario 5 for further analysis, since it represents a reasonable but conservative estimate of the future balance between supply and demand. A key assumption of all scenarios except scenario 1 is that current demand exceeds supply by about 15%. While there is clear evidence from a number of sources that current demand exceeds supply by a substantial amount, the precise amount could be debated. To evaluate the sensitivity of scenario 5 to this assumption, all other conditions were held constant while the extent to which current demand exceeded supply was varied from 5 to 20%. As is evident in Fig. 2, if current demand for endocrinologists exceeds current supply by 10% or more, then future demand is projected to exceed supply from now until 2020. If current demand exceeds current supply only by 5%, then the curves intersect at 2003 and diverge after 2016.

DISCUSSION — The Endocrinology Workforce Model was developed in an effort to determine whether the number of endocrinologists currently being trained is appropriate for future needs. During the development of this model, we were keenly aware that results of previous workforce studies conducted by other disciplines have been criticized for not being objective. Accordingly, we sought to develop a model that was based on conservative assumptions and the demographics of both the current endocrine workforce and the population at large. We also made the model interactive so that the sensitivity of the assumptions can be tested and the predictions updated as additional data become available in the future.

We believe the assumptions used in scenario 5 are realistic, conservative, and defensible. This scenario predicts that demand for endocrinologists will exceed supply from now until 2020. It predicts that the difference between demand and supply will decrease from 2001 to 2010 as additional endocrinologists enter the workforce. The gap will then progressively widen as the large cohort of adult endocrinologists presently older than 50 years leaves practice because of retirement or mortality. These projections imply that the number of endocrinologists being trained is insufficient to maintain access to endocrinologist services at current levels. This conclusion is further strengthened by the results of scenario 6, which takes into account the effects of the rapid increase in the incidence of diabetes that is occurring in virtually every part of the country (15–17). Should the results of

Table 2—*Supply and demand scenarios*

	Supply	Demand
Scenario 1	Current fellowship positions and fill rates persist into future. 457 endocrinology positions, 86% filled. 57% are IMGs; 80% of IMGs remain in the U.S. to practice. No change in retirement rates.	Demand affected only proportionately with population growth.
Scenario 2	All of above assumptions.	Demand exceeds supply by 15% in 1999 (based on trends in patient visits, waiting times, and benchmarking).
Scenario 3	All of above assumptions.	Demand grows in proportion to population. Modest managed care growth: 3% in 2000–2005; 2% in 2006–2010; 1% in 2011–2015. No growth thereafter. (This growth results in a 2% decline in demand for endocrinologists.)
Scenario 4	All of above assumptions.	Demand grows in proportion to population, except that the over-65 population growth results in a 15% greater increase in the demand for adult endocrinologists (see utilization index and ref. 9).
Scenario 5	All of above assumptions.	1% per year growth in per capita real income (a 10% increase in real income is associated with a 2–4% increase in demand) (14).
Scenario 6	All of above assumptions.	Prevalence of diabetes grows by 1% per year and endocrinologists' share grows proportionally.

the Diabetes Prevention Program translate into a decrease in the incidence and prevalence of diabetes in the near future, scenario 6 (which projects the largest gap) would be less likely to occur. Furthermore, the care of patients with diabetes by nonendocrinologists may become more successful as the result of education, technology, and improved pharmacotherapy, which make it easier to care for these patients and thus lessen the demand for endocrinologists.

In computing the balance between supply and demand, we have assumed that the proportion of graduating fellows entering clinical practice will remain constant over the next 20 years. However, this assumption may be incorrect for several reasons. Endocrinology traditionally has been a research-intensive specialty. Therefore, the dramatic increase in both the National Institutes of Health research budget and the proportion of the funds directed toward endocrine-related diseases (e.g., diabetes, obesity, osteoporosis, dyslipidemia, hypertension) likely will increase the proportion of endocrinologists going into research above present levels. In addition, the number of fellows in endocrine training programs has been steadily falling over the last 5 years. This in large part has been due to the reduced funding of subspecialty training programs by Medicare and Medicaid that was initiated in an effort to increase the number of generalists in the U.S. workforce (5). Indeed, this has been very successful, with an overall reduction from 65.2% in 1978 to 39.0% in 1997 in internal medicine residents entering into subspecialization training programs. Unless funding for endocrine fellowships is promptly increased, it is unlikely that this decline will stop abruptly. A high percentage of current endocrine fellows are IMGs (57%) (18). If the recommendations of the Fourteenth Report of the Council on Graduate Medical Education are heeded and the number of IMGs permitted to enter the U.S. workforce is reduced, this could lead to a substantial reduction in the number of practicing endocrinologists in the years ahead (5), even if the fill rate increases to 100%.

The model assumes that endocrinologists who indicated that they were on full-time office staff (10%) or involved in research (4%), teaching (4%), administration (4%), or other (3%) make a negligible contribution to patient care. While this may not be entirely correct, it is highly likely that any such contribution is more than offset by the percentage of time that the far larger number of endocrinologists who indicated they were primarily in office-based practice spend in activities (e.g., teaching and administration) other than patient care. Presently, 70% of practicing endocrinologists are men. On the other hand, the percentage of endocrine fellows that are women has substantially increased over the last several years. Since female physicians work ~10% fewer hours than their male counterparts, an increased proportion of women in the workforce in years ahead may lead to further reduction in the availability of endocrinologists even if the total number in practice does not change (18). We have assumed that rates of retirement for endocrinologists will remain constant over the next 20 years. We believe this is unlikely, since anecdotal evidence suggests that the "pressures of practice"—changes in reimbursement, increasing administrative burdens, and loss of autonomy—are resulting in earlier retirement of physicians who are primarily involved in patient care. Thus, it is likely that we have overestimated the number of clinical endocrinologists who will be active in the workforce during the time frame of our projections.

It is more difficult to estimate demand than to estimate supply. We have taken several approaches to this problem. Both the Medicare BMAD file (6) and the National Ambulatory Medical Care Survey (7) indicate that visits and services (particularly those related to diabetes) performed by endocrinologists increased substantially during the 1990s. The waiting time for an initial appointment is longer for endocrinologists than it is for other physicians. While these observations suggest that demand currently ex-

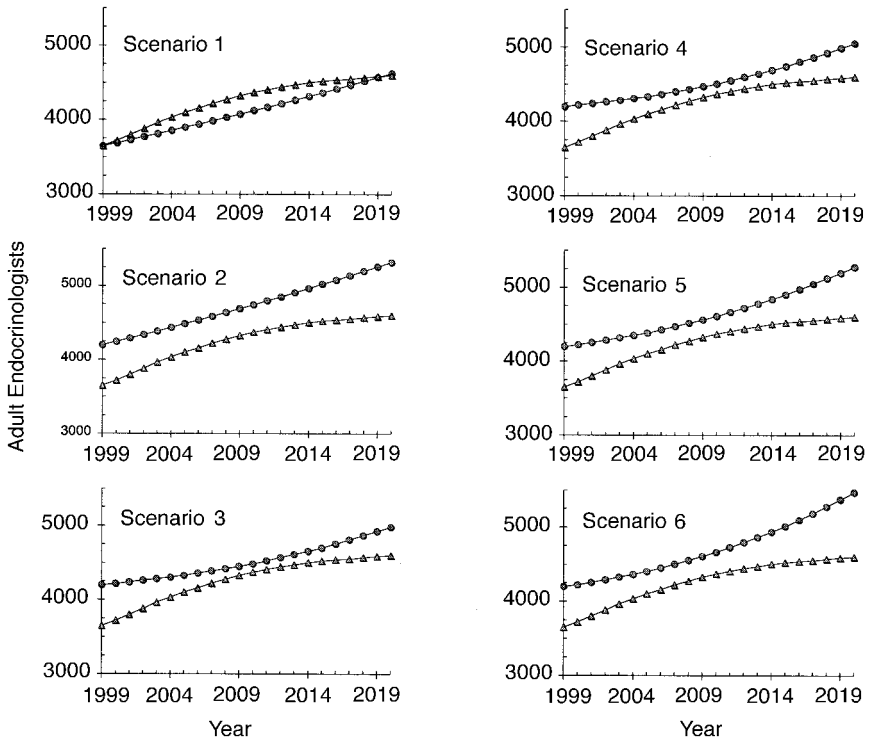

Figure 1—*Projection of supply (triangles) and demand (circles) for adult endocrinologists for scenarios 1–6.*

ceeds supply, they are qualitative rather than quantitative. Scenarios 2 through 6 rely heavily on benchmark data derived from Kaiser Permanente's Mid-Atlantic States Plan. These data suggest that demand for adult endocrinologists currently exceeds supply by ~12%.

Use of the benchmark approach to estimate demand rests on at least six assumptions. First, it is assumed that the "closed" population is receiving all, or almost all, of its actual and contingent care from the panel of physicians and other providers included in the analysis. If there are "leaks" (e.g., care provided to members of the population by providers outside of the panel), the benchmark approach will underestimate demand. Second, it is assumed that the "closed panel" is itself in equilibrium and has the "right" number and mix of providers for the closed population. Third, it is assumed that the endocrinologists in the closed system devote a similar amount of time to other professional activities (e.g., research and administration) as do other clinical endocrinologists. Fourth, it is assumed that if specialists are delivering general as well as specialty care, the proportion is the same as it is in other populations. If endocrinologists in the closed system devote more time to other professional activities or deliver more general care than the "average" endocrinologist in the rest of the U.S., then this approach would overestimate the number of endocrinologists needed outside the closed system. However, we doubt that this is the case, since HMOs generally go to considerable lengths to ensure that specialists are active in patient care and see patients in need of specialty care rather than patients with general medical problems. Fifth, it is assumed that the closed population is representative, in terms of its health care needs and the quality of care received, of the more general population. Finally, it is assumed that the providers included in the closed panel are providing care only to the members of the closed population. Even if these assumptions are valid, it is likely that the benchmark approach used in the present analysis still would underestimate demand in a non-HMO setting, since use of specialists tends to be higher outside than within an HMO. In addition, Kaiser Permanente may be less aggressive in its management style than some other HMOs. In any case, even if Congress does not enact a "Patients' Bill of Rights," access to specialists is likely to increase and active restriction by HMOs of referrals to specialists is likely to be discouraged in the years ahead (19).

Other factors included in the model suggest that we have taken a conservative approach in our estimation of demand. We have assumed that demand for adult endocrinology services in individuals over age 65 years increases at a 15% greater rate than it does in the rest of the population. There is evidence that this is an underestimate. For example, according to the National Center for Health Statistics, older individuals had over twice as many contacts with physicians as those under age 65 years and accounted for 36% of all hospital stays and 49% of all days of care in 1997 (9). We assumed in scenario 6 that the prevalence of diabetes will increase by only 1% per year. Unfortunately, the prevalence of diabetes appears to be increasing much faster than this in almost all age groups and particularly in the elderly (15–17). An increase in participation of nurse practitioners and physician's assistants in the care of people with diabetes is anticipated in the years ahead. However, it is likely that these providers will focus primarily on the type of patient currently being cared for by generalists rather than on the more complex diabetic patients that are typically cared for by endocrinologists.

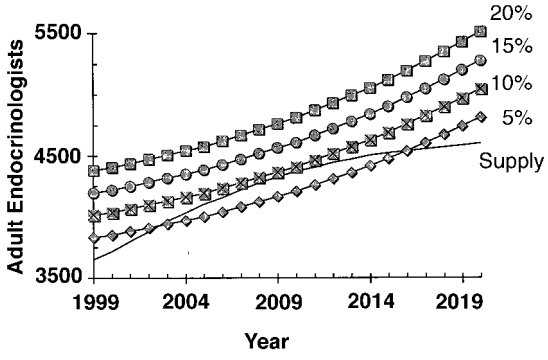

Figure 2—*Effect of varying the estimate of the current gap between supply and demand in scenario five for adult endocrinologists. The solid line shows estimate of supply, and diamonds, crosses, circles, and squares show projections assuming that current demand exceeds supply by 5, 10, 15, and 20%, respectively.*

We are aware that the conclusions of scenarios 2 through 6 differ from the recommendation by COGME that the number of specialists should be decreased (5). However, that recommendation did not specifically address the need for endocrinologists and was made in the absence of data projecting the future balance between supply and demand for endocrinologists. It also preceded the recent recognition by many HMOs of the advantages of having a specialist manage patients whose chronic disease is within their specialty (e.g., endocrinologists for diabetes). Unanticipated events almost certainly will affect our projections of supply and demand. Therefore, the accuracy of the model and its assumptions will need to be reevaluated at regular intervals. However, in view of the consistency of the predictions across the various scenarios and the conservative nature of the present assumptions, it would seem prudent to take steps to ensure that there is no further decrease in number of endocrine fellows in training. If reanalysis in the coming years confirms the trends projected in scenarios 2 through 6, then additional action will need to be taken to increase the number of endocrinologists in practice if a future shortage is to be averted.

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