The Integrative Family Medicine Program: An Innovation in Residency Education

Victoria Maizes, MD, Howard Silverman, MD, MS, Patricia Lebensohn, MD, Mary Koithan, RN, PhD, Benjamin Kligler, MD, MPH, David Rakel, MD, Craig Schneider, MD, Wendy Kohatsu, MD, Meg Hayes, MD, and Andrew Weil, MD

Abstract

The Integrative Family Medicine (IFM) Program is a four-year combined family medicine residency program and integrative medicine fellowship. It was created in 2003 to address the needs of four constituencies: patients who desire care from well trained integrative physicians, physicians who seek such training, the health care system which lacks a conventional integrative medicine training route, and educational leaders in family medicine who are seeking new strategies to reverse the declining interest in family medicine amongst U.S. graduates. The program was designed jointly by the University of Arizona Program in Integrative Medicine (PIM) and family medicine residency programs at Beth Israel/Albert Einstein College of Medicine (AECOM), Maine Medical Center, Middlesex Hospital, Oregon Health & Science University, and the Universities of Arizona and Wisconsin. One or two residents from each of these institutions may apply, and when selected, commit to extending their training by a fourth year. They complete their family medicine residencies at their home sites, enroll in the distributed learning associate fellowship at PIM, and are mentored by local faculty members who have training in integrative medicine. To date three classes totaling twenty residents have entered the program. Evaluation is performed jointly: PIM evaluates the residents during residential weeks and through online modules and residency faculty members perform direct observation of care and review treatment plans. Preliminary data suggest that the program enhances interest amongst graduating medical students in family medicine training. The Accreditation Council of Graduate Medical Education Family Medicine residency review committee has awarded the pilot experimental status.

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The Integrative Family Medicine (IFM) program is a new model for residency training that combines family medicine residency and integrative medicine fellowship programs. Participants in this program are trained in the philosophy and practice of *integrative medicine*, which is defined as "healing-oriented medicine that takes account of the whole person (body, mind, and spirit), including all aspects of lifestyle. It emphasizes the therapeutic relationship and makes use of all appropriate therapies, both conventional and alternative."[1] IFM was created jointly by six institutions (see details below) to address the needs of four constituencies: patients who desire care from well-trained integrative physicians, physicians who seek such training, the health care system (which lacks a conventional integrative medicine training route), and educational leaders in family medicine who are seeking new strategies to reverse the declining interest in family medicine amongst U.S. graduates.

Please see the end of this article for information about the authors.

Correspondence should be addressed to Dr. Victoria Maizes, Executive Director, Program in Integrative Medicine, Associate Professor Clinical Medicine, Family and Community Medicine, and Public Health, University of Arizona, PO Box 245153, Tucson, AZ 85724; telephone: (520) 626-6417; fax: (520) 626-3518; e-mail: (vmaizes@ahsc.arizona.edu).

Family medicine residents at six pilot sites around the country can apply during their first year of residency to participate in the IFM program. Each year, one or two residents per site are selected and agree to extend their family medicine training from three to four years. They complete their entire family medicine residency at their home site. In addition, in their second year of residency they enroll as associate fellows in a 1,000-hour distributed learning fellowship in integrative medicine taught by the University of Arizona Program in Integrative Medicine. IFM residents learn integrative medicine from University of Arizona faculty during three residential weeks in Arizona and from the online curriculum and are mentored by their local residency faculty who have training in integrative medicine. Evaluation is shared; the University of Arizona carries out evaluation activities during residential weeks and in online modules, and residency faculty members perform direct observation of care and review of treatment plans. To date three classes totaling twenty residents have enrolled in the IFM program.

Background

Patients use complementary and alternative medicine (CAM) in large numbers. The most recent data reported by the Centers for Disease Control and Prevention reveals that 62% of the U.S. population uses CAM.[2] A qualitative study of women with breast cancer (in which 72% were using one or more CAM therapy) revealed that the women valued their physicians' respect and understanding regarding treatment choices. However, these women mostly perceived their doctors would not be interested in their use of CAM, would respond negatively, or would be unable to offer any useful information.[3] A survey of parents revealed that 75% of those who used CAM themselves and 81% of those who used CAM for their children would like to discuss CAM therapies with their pediatrician.[4]

Most physicians however, feel unprepared to answer questions about CAM. A survey of Colorado physicians

found 60% thought they needed to learn more about CAM to adequately address patient concerns.[5] A survey of Canadian family physicians revealed that 71% were interested in evidence-based CAM information, and 69% agreed that physicians should be knowledgeable about CAM.[6] Medical students want CAM to be included in their training.[7] Although medical schools have begun to incorporate some training in CAM, it is predominately offered as electives and often not well integrated into the curriculum.[8]

Integrative medicine educational programs are growing in number. The National Center for Complementary and Alternative Medicine has funded fifteen R25 educational grants to incorporate CAM into medical, nursing, and residency training.[9] The Consortium of Academic Health Centers for Integrative Medicine now has 31 member institutions, most of whom have significant educational programs in integrative medicine.[10] Learning objectives in CAM for medical students and residents have been published.[11,12] A recent Institute of Medicine report emphasized the need for all physicians to become familiar with CAM approaches so they can properly counsel their patients regarding their use.[13]

Although many medical schools and residencies have sought to incorporate training in integrative medicine into their curricula, they have faced significant barriers.[11] Availability of faculty trained in the field, the already crowded curricula, and the additional expense have limited the extent of such training. A satisfactory model for the incorporation of substantial training in integrative medicine into conventional medical education has yet to emerge. Most programs are either elective or continuing medical education/ fellowship-level programs reaching only a small number of physicians-in-training. The IFM program was designed to address these barriers. The portability of the University of Arizona associate fellowship program (described below), the comprehensive curriculum, the decision by the six family medicine residency programs to extend training to four years, and funding by the United States Department of Education, made the creation of the pilot version of the IFM program possible.

Selection of primary care residency training has declined significantly amongst graduates of U.S. medical schools.[14] After steady increases in interest in family medicine from 1992–1997, the trend reversed between 1997–2005. For example, the percentage of graduating U.S. medical students choosing family medicine in the National Residency Matching Program (NRMP) shrank from 16% in 1997 to 7.7% in 2005. In 1997, 3,262 family medicine residency positions were offered and 2,340 (71.7%) were filled with U.S. graduates.[15] In 2005, 2,782 positions were offered in family medicine and 2,292 (82.4%) positions were filled through the NRMP; however, only 1,132 (40.7%) were U.S. graduates. Many of the international graduates return to their native countries to practice, reducing the supply of primary care physicians in the United States, especially in rural areas.[16]

Several recent studies commissioned by the American Academy of Family Physicians (AAFP) explore the declining interest in family medicine. One study surveyed graduates of 24 U.S. medical schools regarding their specialty choices of family medicine, internal medicine, medicine, and pediatrics. The study found that students were concerned about their ability to develop competency in the broad scope of family medicine with only three years of training.[14]

The AAFP, the American Board of Family Medicine, Association of Departments of Family Medicine, Association of Program Directors of Family Medicine, the North American Primary Care Research Group, and the Society of Teachers of Family Medicine commissioned a multipart national study that resulted in a report about the future of family medicine.[17] To enhance the training of family physicians, the authors recommend that the school's Residency Review Committee (RRC) "permit active experimentation and ongoing critical evaluation of competency-based education." One suggested experiment was to extend family medicine training to four years.

The report offers recommendations for a new model of practice and training in family medicine. Specific recommendations include a focus on developing and strengthening key attributes of family physicians such as "a deep understanding of the dynamics of the whole person," "a generative impact on patients' lives" so that physicians may foster the personal growth of their patients and assist them in achieving improved health and wellness, "a talent for humanizing the health care experience," "a natural command of complexity," understanding the physician's role as being more than that of a provider of "pills and procedures," and "a commitment to multidimensional accessibility," including good communication with all those involved in the patient's care. These characteristics are significant features of integrative medicine training, thus strengthening the impetus for the IFM program.

Creation of the IFM Program

The IFM program was jointly created in 2003 by faculty at the University of Arizona Program in Integrative Medicine and by family medicine faculty from Beth Israel/AECOM (New York, New York), Maine Medical Center (Portland, Maine), Middlesex Hospital (Middletown, Connecticut), Oregon Health & Science University (Portland, Oregon), the University of Arizona (Tucson, Arizona), and the University of Wisconsin (Madison, Wisconsin). These six sites were selected with diversity and generalizability in mind and include urban and suburban, community, and university-based programs. All sites have faculty trained in integrative medicine to provide onsite mentoring and supervision of residents. The department chairs promised to provide salary support for the IFM residents who would be extending their residency training by a fourth year and to support their identified faculty member's time on the project.

The curriculum and evaluation processes were devised during onsite retreats and monthly conference calls. The curriculum balances uniformity of training with flexibility and consists of core requirements and elective activities. The implementation of the curriculum is flexible so that diverse residency programs can incorporate the program into their existing structures. During the first faculty retreat in September 2003, two overall goals were established for the program:

1. The program will be developed and implemented so that it can become an accredited model for a four-year program that integrates training in

integrative medicine with conventional family medicine residency training.

2. Graduates will manifest the philosophy and practice of integrative medicine.

It was also decided that the Program in Integrative Medicine associate fellowship training program at the University of Arizona would be used as the primary curricular delivery approach. The Program in Integrative Medicine initiated development of a comprehensive curriculum in integrative medicine in 1994. Three years later, a two-year residential fellowship program was launched.[18] The residential fellowship was designed as a "train the trainer" model and was limited to four fellows per year. While many of the graduates have become academic leaders of integrative medicine programs, the need for a larger training program was clear. In 2000, the Program in Integrative Medicine adapted its curriculum and initiated a two-year distributed-learning associate fellowship program.

IFM program residents from the six pilot sites join the larger associate fellowship class in January of their second year (i.e., after 1.5 years of family medicine residency training). Clinical supervision takes place at the individual residency sites, and residents are mentored by the selected faculty expert. Thus the IFM program is a hybrid of the residential and associate fellowship programs at the University of Arizona and incorporates aspects of both programs. Further characteristics of the IFM program's curriculum are described in List 1.

In brief, the curriculum provides a strong knowledge component via the associate fellowship, a clinical component in the outpatient setting with continuity as well as consultation sessions and case conferences, an experiential component, opportunities to learn about other modalities and in-depth training in one of them, and a reflective, self-care component that emphasizes the embodiment model of integrative medicine. The IFM program is designed to extend the current family medicine paradigm beyond the biopsychosocial model. The goal is not to create a new family medicine subspecialty or certificate of added qualification; rather, it is to educate family physicians who practice medicine in an integrative manner.

Once the program goals and values were adopted and the basic curricular assumptions and framework were outlined, the faculty met for a second retreat in 2004 to further refine core programmatic components and develop an evaluation strategy. Behavioral competencies (List 2) were identified after reviewing recently proposed integrative medicine core competencies for medical school curricula[4] and the general residency competencies of the Accreditation Council for Graduate Medical Education (ACGME).[19]

An evaluation plan was designed to address the decentralized nature of the IFM program and the diversity among implementation sites, focusing on (1) the core programmatic competencies, (2) the curriculum design, and (3) the potential impact of the IFM program on the family medicine residency environment. Evaluation strategies (List 3) were selected based on faculty experience with the measures, a review of the evaluation literature, recommendations from the ACGME Outcomes Project, and measures currently used in the participating family residency programs.

List 1

Characteristics of the Integrative Family Medicine Program Curriculum, 2006

Residents in the Integrative Family Medicine Program participate as Associate Fellows in the University of Arizona Program in Integrative Medicine.

1. This program is a two-year Web-based curriculum in integrative medicine. Learning occurs through interactive content and exercises on the Internet site, threaded dialogues, reading and CD-ROM assignments, in-home herbal, acupuncture, and homeopathy labs, and community assignments. The program includes three residential weeks in Tucson designed to build community among the participants, as well as to provide hands-on experience with integrative medicine.
2. The residents are expected to spend an average of six hours a week studying the online curriculum.

Integrative medicine is gradually incorporated into the outpatient setting with faculty supervision.

1. Residents apply the principles of integrative medicine in their continuity clinics. In addition to the 1,650 required patient visits in residency years 1 through 3, fellows continue their continuity care clinic in the fourth year.
2. In the fourth year fellows participate in an integrative consultation outpatient service. They see patients referred to them from other clinicians and offer comprehensive evaluation and treatment plans.
3. Fellows must have a minimum of 50% clinical activities in the fourth year.

Self-care is emphasized and incorporated as a core part of the curriculum.

1. In consultation with faculty, each trainee will establish and periodically update a self-care wellness plan to establish a balance between professional activity and personal well-being.
2. Time will be allotted for implementation of the trainees' self-care wellness plan.
3. Reflection activities will be regularly scheduled to explore the process of becoming an integrative family physician.

Fellows are expected to develop competency in defined core curricular areas, learn different modalities in integrative medicine, and to select one modality for more in-depth training.

Experiential learning is emphasized, including experiencing treatment modalities.

Fellows have responsibility to teach and perform scholarly work, including presentation, research, and publication.

Fellows perform some kind of community service.

Additional teaching methods include (but are not limited to):

1. Integrative medicine patient care continuity experience
2. Continued primary care continuity clinic through all four years of training
3. Integrative medicine consultation clinical experience in the fourth year
4. Regularly scheduled multidisciplinary case conference

Faculty trained in integrative medicine who embody the philosophy of practice of integrative medicine are actively involved in training and mentoring.

List 2

Core Competencies to be Achieved by Residents in the Integrative Family Medicine Program, 2006

1. Practices self-care.
2. Demonstrates self-awareness.
3. Uses patient-centered care techniques.
4. Uses communication skills that enhance the physician/patient relationship.
5. Facilitates lifestyle changes in patients.
6. Knows how to refer appropriately to practitioners of complementary and alternative medicine (CAM).
7. Practices constructively and collaboratively with other health care team members.
8. Assesses scientific and historical evidence for allopathic as well as CAM approaches to specific diseases and syndromes.
9. Integrates mind-body recommendations into practice appropriately.
10. Integrates botanical recommendations into practice appropriately.
11. Integrates nutrition recommendations into practice appropriately.
12. Integrates physical activity recommendations into practice appropriately.
13. Counsels and supports patients regarding spirituality.
14. Composes and administers individualized integrative medicine treatment plans.
15. Positively influences their organization and/or environment (local, regional and/or national) with regard to integrative medicine (which might translate into consulting, teaching, advocacy).

The IFM Program's Implementation, Preliminary Outcomes Data, and Impact

Implementation

The criteria and interview process for selecting residents to be trained in the IFM program were individually determined by the six participating family medicine residency programs. All residents had to be in good standing within their programs and all had to have completed the application process for the associate fellowship. One or two positions were made available to each residency program. Each program weighed the value of two participants against the cost of providing two salaries for fourth-year residents; most sites had more interested candidates than IFM positions.

We applied to and received approval from the ACGME's Family Medicine RRC for pilot status. On February 16, 2004, we were notified that "the RRC voted to encourage the participating programs to pursue the integration of Integrative Medicine into their residency programs." It is worth noting that this is only the second time in the history of that RRC that approval for implementation of an experimental program has been awarded.

Outcomes

The family medicine residency environment. Preliminary outcomes evaluation of the IFM program began with the first class' residential retreat in January 2004. Of the methods identified in List 3, we have implemented all but the online mini-portfolio and the patient survey. While it is premature to assess all of the specific behavioral competencies in this population of residents, we report below our initial findings on the impact of the IFM program on the family medicine residency environment at each site and on the achievement of various competencies by the residents in the IFM program.

During the first residency recruiting season (2003–04), all participating faculty anecdotally noted an increase in the level of interest in the IFM program by interviewees. In addition, several medical students acknowledged visiting all six participating residencies during 2003–04 in order to secure a position in an IFM program's participating residency. By the 2004–05 residency recruiting season, we had implemented our evaluation plan and established more formalized procedures to evaluate whether the IFM program would bring more applicants to the participating residencies and to assess the quality of those applicants.

Data were collected from the residency program directors of each participating site immediately after the Match. Four initial questions were asked, soliciting their opinion regarding the impact of the IFM program on their Match outcomes and process. All program directors (100%, $n = 6$) indicated that there was a positive impact on recruiting from the IFM program. Also, three of those asked agreed the presence of the IFM program brought in more desirable applicants, and five thought the program also brought in more applicants.

Recognizing the subjective nature of these self-reported ratings, we also collected rank lists and applicant ratings on stated level of interest and overall quality/desirability for all family medicine residency applicants from all participating programs. Applicants were identified by the program directors as either "highly interested," "moderately interested," or "not interested" based on the applicants' statements of interest during the application, interview, or matching processes. In addition, program directors could identify that they "did not know" the interest of the applicant. Applicant quality/desirability was also rated by the program directors ("high quality," "moderate quality," and "poor quality") and was based on an evaluation of application materials and interview outcomes as well as their comparative ranking among current year applicants.

Of the "high quality" applicants ($n = 108$), 27 (25%) were highly interested in the IFM program and an additional 15 (14%) were moderately interested, compared to only six (5%) who expressed no interest. Conversely, among the "low quality" applicants ($n = 19$), only two had a high interest in the IFM program, only two were moderately interested, and five had no interest. Subsequent analysis using Kendall's tau and Spearman's rho correlations confirmed the impact of the IFM program on the matching process (Table 1). Kendall's Tau correlations were used to compare applicant ranking score and interest in IFM and applicant quality and interest. Spearman's rho correlations were used to compare actual ranking quartile (1–4) and interest.

List 3

Competency Evaluation Strategies Used to Evaluate Fellows in the Integrative Family Medicine Program, 2006

Primary methods

University of Arizona measures

- Focused self-care plan
- Abrams' transformation survey
- Well-being self evaluation instrument
- Belief statement self evaluation
- Patient survey
- OSCE I and II
- Knowledge assessments (nutrition, botanicals, mind-body interventions, physical activity, spirituality)
- Integrative medicine knowledge-skills-attitudes self rating scale
- Patient case scenarios
- Referral network evaluation
- Research critique and review assessment
- Alumni survey

Local residency measures

- Direct clinical observation
- Treatment plan evaluation
- Online mini-portfolio
- Faculty/peer/rotation performance evaluations

Secondary method

- Knowledge assessments/examinations

Chi square analysis also confirmed that there was a significant difference among the four quartiles on interest in IFM ($\chi^2 = 20.62$, $p = .05$). Of those highly interested in IFM ($n = 39$), 27 (69%) were ranked in the first two quartiles. And of those that were highly ranked (quartile 1), 12 (30.8%) were highly interested in IFM, compared to 5% who were not interested.

These data are limited in two respects. First, many of the program directors rated the applicants retrospectively based on interview notes and records review. Second, due to the retrospective nature of the data collection process in the 2004–05 residency recruiting season, over 50% of the applicants' interest in IFM was "unknown." Revisions have been made to the data collection process to assure prospective data collection on these items during the 2005–06 recruiting season. Yet, these preliminary analyses point to a potential positive impact of the IFM on the quality and quantity of family medicine resident applicants.

Residents' competencies. In February 2005, we conducted a one-station objective structured clinical examination (OSCE) of all associate fellows, including the initial class of six IFM residents to evaluate their achievement of competencies associated with the (1) use of patient-centered care techniques, (2) use of communication skills that enhance the physician/patient relationship, and (3) ability to perform an integrative health history and patient assessment. Patient actors measured 25 behavioral items expected to be present following completion of the first year of the IFM program (these items are also expected to be present for all associate fellows). These included (1) gave verbal/nonverbal positive reinforcement, (2) used open-ended rather than forced-choice questions, (3) said in some manner "Your problem is significant and interfering with your life," and (4) made eye contact.

Total OSCE scores ranged from 80–100%, with a mean score of 90% (SD = .075) and a median score of 90%. Individual item scores ranged from 67% to 100%, with a mean item score of 90% (SD = .096) and a median score of 83%. The six IFM program residents each questioned the patient about spirituality and spiritual practices as well as nutrition and diet, and five questioned the patient about the use of botanicals and supplements, nonphysical aspects of the health history, and use of CAM or alternative health care interventions. The behavior missed by two of the residents was "encouraged questions about the chief complaint and other issues at the end of the encounter."

These findings are limited by the small sample size and the lack of a comparative group of family medicine residents to determine if this group of residents was relatively more competent in these skills than peers who have not engaged in the IFM program. Several items point to areas that require additional attention in either didactic or clinical IFM program experiences. Yet, these preliminary results indicate that overall this initial class of IFM program residents are competent in patient-centered communication skills and are able to consistently conduct an integrative health history and patient assessment.

Obstacles and Challenges

The greatest challenges for the IFM program have been time, finances, and the multiple locations. The residents felt that, especially during the second year of their training, that the time required for the online curriculum was beyond that available in their work schedule. Several program directors agreed to free the resident from other responsibilities for one half-day each week. However, this proved to be impossible during the more rigorous ward months due to the impact on their colleagues. Time challenges became less daunting for residents in the third year of training.

Many residents used elective time to "catch-up" on the online curriculum; in general this was not ideal as they missed the opportunity to participate in the interactive online discussion while it was being moderated by a faculty member, an important part of the associate fellowship curriculum. If the online curriculum continues to serve as the primary curricular delivery method for this program, we will have to find ways to

Table 1

Comparison of Applicant Quality, Interest in the Integrative Family Medicine (IFM) Program, and Residency NRMP Ranking 2004–2005*

Residency program and no. residents	Quality and interest	Rank and interest	Quartile rank and interest
Beth Israel/Albert Einstein College of Medicine; 48	−.013	−.070	−.085
Maine Medical Center; 51	.339‡	.229†	.247†
Middlesex Hospital; 32	.190	.089	.049
University of Arizona; 30	.573‡	.443†	.436†
University of Wisconsin; 78	.104	.347‡	.379‡
Total IFM program; 239	.161‡	.291‡	.187‡

* The data were gathered retrospectively by asking program directors to subjectively assess the overall quality of their applicants and the expressed interest of the applicant in the IFM program. NRMP match lists from each residency devoid of specific applicant identifying data were provided to the evaluation researcher (MK). Kendalls T and Spearman Rho correlation statistics were used to determine the correlation between quality of the applicant (rated as high, moderate and low by program directors), interest in the IFM program (rated as high, moderate and low by program applicants) and quartile ranking score (1–4 as determined by the actual Match ranking score received by the applicant from the residency program faculty). Quality, interest and quartile ranking were all found to be highly correlated within the total program and more closely associated in programs at Maine Medical School, the University of Arizona and the University of Wisconsin.
† $p < .05$.
‡ $p < .001$.

allow residents full participation during their second year. A final time challenge has been prioritizing time for self-care; in general, this has not been a valued part of postgraduate education.

The financial challenge has also been significant. Because this pilot program was granted "experimental" accreditation by the RRC, the fourth year of residency does not qualify for Medicare pass-through funds, which support residents' salaries in the first three years of training. Full accreditation status through the ACGME's RRC, the program's ultimate goal, would solve this problem. In the interim, each of the sites has addressed salary support for the fourth year in its own way. Strategies include the use of faculty development grant funds for the fourth year of residency training; the reconfiguration of a family medicine program from eight residents per year for three years to six residents per year for four years—enabling the same amount of funds to be used over a longer period; private foundation support; and use of the revenue generated by the clinical work of the fourth-year residents to cover salary costs. The latter strategy potentially puts the educational experience of the resident at risk in favor of the pressure for productivity.

The second financial challenge is the need for continued support to underwrite the costs of the associate fellowship program. The U.S. Department of Education has offset the University of Arizona College of Medicine's costs for faculty time, annual retreats, and the evaluation of the program. If these funds become unavailable, ongoing access to the associate fellowship will have to be funded in another way. Expanding access of the IFM program to the associate fellowship as this program moves beyond the six pilot schools offers both significant challenge and opportunity for innovation.

Mentored online distributed learning programs such as the associate fellowship may prove to be the ideal educational system for residents whose clinical responsibilities often leave scheduled lectures poorly attended. Comprehensive, interactive learning can fit into the less busy times in residents' schedules. In addition, distributed learning may ultimately prove to be more cost-effective and offer greater curricular consistency.

A final challenge is the multicenter nature of this project. While the value to the pilot of diversity is clear, scheduling conference calls and retreats across time zones and faculty schedules is difficult. Evaluation is significantly affected as well; consistency of data collection including timing, completeness, and interrater reliability issues grow in complexity when carried out across the six sites.

Summing Up

The Integrative Family Medicine program is a unique pilot program which weaves together family medicine training with an integrative medicine curriculum to create a new model for postgraduate training of family physicians. Designed as an embodiment model, it encourages residents to gradually integrate all that they learn into their patient encounters. The project embraces characteristics of the New Model of Family Medicine outlined by the report on the future of family medicine mentioned earlier.[17] It emphasizes relationships between patients and physicians, comprehensive care, and the commitment to provide all of family medicine's services, now expanded to include evidence-based complementary and alternative medicine practices.

Early results suggest the program leads to enhanced interest in family medicine amongst graduating medical students, thus offering a potential solution to the reduced interest in this primary care specialty. The unique delivery method challenges medical educators to consider which of their own curricular efforts might best be moved to online learning. The IFM program evaluation is designed to assess the development of competency in integrative medicine amongst family medicine residents. This represents a first for the field of integrative medicine and is a critical part of obtaining ACGME accreditation. Ultimately, the Integrative Family Medicine program project goes beyond developing competency in integrative medicine and has the potential to enhance family medicine as a whole.

Dr. Maizes is executive director, Program in Integrative Medicine, University of Arizona, and associate professor of clinical medicine and family medicine, College of Medicine and the College of Public Health, University of Arizona, Tucson, Arizona.

Dr. Silverman is education director, Program in Integrative Medicine, University of Arizona, Tucson, Arizona.

Dr. Lebensohn is program director, Family Practice Residency Program, University of Arizona, Tucson, Arizona.

Dr. Koithan is coordinator of educational research and evaluation, Program in Integrative Medicine, University of Arizona, Tucson, Arizona.

Dr. Kligler is research director, Continuum Center for Health and Healing, and associate professor of family medicine, Albert Einstein College of Medicine, New York, New York.

Dr. Rakel is director of integrative medicine, School of Medicine and Public Health, and assistant professor, Department of Family Medicine, University of Wisconsin, Madison, Wisconsin.

Dr. Schneider is director of integrative medicine, Department of Family Medicine, Maine Medical Center, Portland, Maine.

Dr. Kohatsu is assistant professor, Department of Family Medicine, Oregon Health & Science University, Portland, Oregon.

Dr. Hayes is assistant professor of family medicine and co-director of the Integrative Medicine Fellowship, Family Medicine Department, Oregon Health & Science University, Portland, Oregon.

Dr. Weil is founder and director, Program in Integrative Medicine, and clinical professor of medicine and public health, University of Arizona, Tucson, Arizona

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Did You Know?

A researcher at Stony Brook University School of Medicine, in 1973, developed an imaging technique for taking three-dimensional pictures of body organs and vessels without the use of ionized radiation or toxic dyes. This technique was used as the basis for the manufacture of MRI equipment.

For other important milestones in medical knowledge and practice credited to academic medical centers, visit the "Discoveries and Innovations in Patient Care and Research Database" at (www.aamc.org/innovations).