Development and implementation of a biomedical informatics course for medical students: challenges of a large-scale blended-learning program

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ABSTRACT

Biomedical informatics (BMI) competencies are recognized as core requirements for the healthcare professional, but the amount of BMI educational interventions in the curricula of medical schools is limited. UNAM Faculty of Medicine in Mexico is a large public medical school, with more than 7000 undergraduate students. The undergraduate program recently underwent a major curricular revision, which includes BMI education. Two one-semester BMI courses (BMI-1 and BMI-2) were designed, with a blended-learning educational model. A department of BMI was created, with budget, offices and personnel. The first class of 1199 students started the course in 2010, with 32 groups of 40 students each. BMI-1 includes core conceptual notions of informatics applied to medicine (medical databases, electronic health record, telemedicine, among other topics), and BMI-2 embodies medical decision making and clinical reasoning. The program had a positive evaluation by students and teachers. BMI can be successfully incorporated in a large-scale medical school program in a developing country, using a blended-learning model and organizational change strategies.

BACKGROUND

The training of competent healthcare professionals is one of the most complex challenges facing education at present.[1] One of the main competencies that are indispensable to practice quality medical care in the current healthcare arena is the utilization of informatics.[2] Despite the advances and contributions to healthcare that informatics has produced in the past decades, these have not been commensurate with the actual importance given to its teaching in medical schools, as reflected by the limited inclusion of formal biomedical informatics (BMI) teaching in medical schools' curricula.[3–5]

The Association of American Medical Colleges has recommended the inclusion of informatics in the curriculum,[1] but medical schools have been reluctant to add courses or hours of formal training to their already saturated programs. There is a relative lack of full-time BMI scholars in medical schools and academic centers, which makes the implementation of BMI academic activities an uphill endeavor.[6] These factors have multiple aspects depending on the individual settings of medical schools and healthcare systems, which require a mixture of global and local perspectives to be addressed effectively.

Curricular change is a complex task that medical schools traverse in their journey to reach their institutional mission and vision. This process is fraught with challenges and opportunities, and requires specific strategies to achieve a successful outcome.

This educational case report describes the design and implementation of a formal BMI curriculum in a medical school in Mexico, and the lessons learned during the process.

CASE DESCRIPTION

The National Autonomous University of Mexico (UNAM) Faculty of Medicine is one of the largest medical schools in Latin America, with more than 7000 undergraduate students. It is a public institution founded more than four centuries ago, and has been the main source of Mexican medical professionals and scholars since its inception. In consequence, it is a traditional organization that has an intricate bureaucracy, creating a difficult scenario to effect change.

Our medical school undergraduate curriculum has remained essentially the same since 1993, so a curricular revision was deemed necessary. In 2008 a curriculum task force was created, which worked following the principles of effective curricular change, including internal networking, participative leadership with the organization's members and taking into account the organization's structure, among other things.[7] A major curricular reform was designed, with several novelty elements (generic outcome competencies, formal diagnostic testing, and new mandatory courses on BMI, basic–clinical integration, professionalism, evidence-based medicine), and retaining components that took advantage of our institution's positive qualities and resources. The new curriculum underwent the formal university process for approval, and was initiated in the academic year 2010–11.[8]

The new program has a 6-year duration, with 2 years of mostly basic sciences courses, 2 years of clinical sciences, 1 year of internship and 1 year of social service, which is required of all medical schools in Mexico. The curriculum includes clinical courses and discussion of patient problems from the first year. In Mexico the study of medicine is an

undergraduate career, which begins after finishing high school. There are more than 70 medical schools in the country, and from a review of their websites and personal contacts, it is apparent that the majority of them do not have an explicit component of BMI. Several schools include some component of informatics in their programs, but many of them are focused on the tools of productivity (eg, use of Microsoft Office, email, etc), not on the broader constructs of BMI championed by the international leaders in the field. This paper describes the development and implementation of two innovative BMI courses that are part of the new curriculum, with a focus on their organization, educational methods and logistics.

METHODS

A thorough needs assessment process for the whole curriculum, and for the BMI discipline in particular, was undertaken following the model of Kern *et al*.[9] This included surveys, interviews with students, teachers and practicing clinicians, focus groups, and an extensive review of the literature and available curricula of medical schools. A hybrid curriculum that included terminal generic competencies and traditional discipline-based courses was designed by a team of educators, clinicians and discipline-specific experts, with input from the teacher and student community.

Eight generic competencies that must be achieved by graduation were defined after a review of the literature and consensus of the medical school faculty (see supplementary appendix 1, available online only). One of the competencies includes the management of information, which provides the opportunity to introduce the field of BMI at different levels in the educational network of the basic and clinical courses of the medical curriculum.[10]

BMI courses were included in the first and second year, and an evidence-based medicine/clinical epidemiology course in the third year, in order to have an explicit longitudinal track related to informatics in the first 3 years. The BMI courses are one semester each, with 34 mandatory curricular hours per course. The BMI-1 course occurs in the first year and BMI-2 in the second year. The courses were designed specifically for the medical students, and their initial requirements were the informatics skills that are required to succeed in the higher education system (use of word processing, spreadsheets, presentation software, email, internet and system maintenance and security). The first-year students had the following courses while they were taking BMI-1: anatomy, biochemistry and molecular biology, embryology, cell biology, introduction to mental health, public and community health and basic–clinical integration I; the second-year students had the following simultaneous courses: pharmacology, immunology, physiology, introduction to surgery, basic–clinical integration II and promotion of health in the life cycle.[8]

The content of the BMI courses was based on a review of the relevant literature, including the major text in the field,[11] the International Medical Informatics Association recommendations on education in biomedical and health informatics,[12] and the published papers related to the teaching of BMI.[13 14] A team was integrated with experts in medical education, clinicians and informatics specialists to develop the educational content and methods to be used in the courses, taking into account the realities of the Mexican healthcare system, the epidemiological and the public health data of our population.

The main educational goals of the BMI-1 course are that medical students, by the end of the course, have achieved the following:

- Acquisition of the knowledge, skills and attitudes needed for searching, identification, analysis and effective application of biomedical information in the practice of medicine at the level of a general practitioner.
- Ability to describe the advances in information and communication technologies relevant to general medicine.
- Capacity to utilize informatics resources rationally in medical practice at the level of a general physician.

The main educational goals of the BMI-2 course are that medical students, at the end of the course, have achieved the following:

- Acquisition of the knowledge, skills and attitudes necessary for effective decision making under conditions of uncertainty, for the practice of general medicine.
- Ability to understand and apply current concepts about clinical reasoning, relevant to the general practitioner.
- Capacity to identify the informatics advances for support of clinical decisions, at the level of a general physician.

Two one-semester courses (34 h/semester) were designed, including most major themes of BMI relevant to medicine (tables 1 and 2). We decided to use a blended-learning model to take advantage of both modalities (online and face to face). A virtual learning environment was designed with the Moodle platform, for student and teachers' work, which included links to all the course units, reading materials, PowerPoint presentations and several useful resources (BMI websites, dictionaries, medical databases; figure 1). Individual educational objectives for each session were developed, and didactic guides were designed for both professors and students, with a detailed description of the session activities. Some examples of the teachers' didactic guides for the session educational activities are included in supplementary appendix 2 (available online only). The full set of teacher and student guides, as well as the PowerPoint presentations are available in Spanish from the authors.

A group of teachers met regularly during the course to design the educational activities of each session, including objectives, reading material, PowerPoint presentations, online synchronous activities, homework, and formative and summative exams, and to discuss the ongoing feedback obtained from students and faculty. An overriding principle for the educational activities was that each session was designed around a clinical problem, starting with a vignette that was understandable for the students' beginner level and that was relevant to the practice of general medicine in Mexico.

One of the challenges of the program is the establishment of integration links with the rest of the curriculum and the healthcare system. The following strategies were implemented to promote integration: at the curricular level integration was promoted through the definition of the generic outcome competencies to be reached at the end of the program, and the explicit documentation of different levels of mastery for each medical school block and its assessment criteria;[8] an interdisciplinary faculty development program was implemented for the new curriculum, which included training in competency-based education and assessment with emphasis on integration; a new 4-year longitudinal course on integration (of basic and clinical sciences) was designed, which includes links to all the simultaneous courses that students take every year; the clinical cases for the integration courses were written by a group of professors from every discipline, and were designed to promote learning oriented to the relevant competencies; and practising clinicians were included in all these activities, to maintain a direct contact with practice in the healthcare system. There was an explicit effort to link this course with the others (eg, public health,

Table 1 BMI-1 course content in UNAM Faculty of Medicine 2010 MD program

Unit	Theme	Subthemes
1	Introduction to BMI	► Definition of BMI. ► Historic development of BMI. ► Current and future perspectives of BMI.
2	Essential concepts in BMI	► Data in medicine: acquisition and use. ► Information and knowledge taxonomy (DIKW). ► Hardware and software: structure and function of computers. ► Information and communications technology. ► Standards in BMI. ► Technology evaluation.
3	Databases and medical digital libraries	► Main sources of biomedical information. ► Tools and strategies for biomedical information searching.
4	Internet and the medical profession	► History and definition of Internet, WWW, Web 2.0, Health 2.0 ► Use of the internet for the medical professional: advantages, limitations and challenges.
5	Cybermedicine	► Electronic health record. ► Hospital information systems. ► Imaging informatics and radiology. ► Interinstitutional health information systems. ► Artificial intelligence (expert systems). ► Telemedicine. ► Robotic medicine. ► Simulators in medicine. Virtual reality.
6	E-learning	► The net generation: social and educational aspects. ► Virtual learning environments. ► Wikis, blogs, podcasts, vodcasts, Twitter, Facebook. ► Use of technology in scientific presentations (PowerPoint, Prezi, etc).
7	Bioinformatics (biomolecular informatics)	► Definition of bioinformatics. ► Applications in molecular biology, genomic medicine and clinical practice.
8	Ethics and BMI	► Social challenges and ethical implications of BMI. ► Informatics and its influence in the physician–patient relationship. ► Legal aspects of BMI.

BMI, biomedical informatics.

pharmacology, etc) and with the generic competencies of the new curriculum, including the clinical cases and assignments relevant to the other areas.

The didactic activities were designed to be locally relevant, while addressing global issues. An example was the session on telemedicine, in which even though the Mexican federal telemedicine program does not cover the majority of the population, students should be aware of its potential and recognize that some form of teleconsultation can be performed in our settings. The session case is a patient with abdominal pain in a small town in the Mexican province, using Skype to consult with a surgeon for referral. Medical students in developing countries need to be exposed to the realities of their healthcare system, while being aware of the enormous potential for the use of technology in healthcare improvement. The didactic sessions were designed to address this paradox.

Another resource was the publishing of a textbook in Spanish about BMI, to provide the factual information, content description, and practical activities related to the course. The students required a common source in their native language to study for classes and exams, so a project with a major medical publisher was completed.[15] There are few BMI textbooks targeted to the undergraduate medical student population, the major sources (books and journals) are aimed at the practising informaticist or postgraduate students.

As a result of the approval of the new curriculum, an organizational structural change occurred with its attendant resource allocation, because university regulations mandate that new courses must be coordinated by formal academic departments. A new academic department of BMI was created to provide infrastructure and support to the new courses, this decision included physical spaces, classrooms, offices and budget.

Table 2 Content of the BMI-2 course in UNAM Faculty of Medicine 2010 MD program

Unit	Theme	Subthemes
1	Medical decision making	► Uncertainty and probability in medicine. ► Experience and probability in medicine. Cognitive heuristics (representativeness, availability, anchor and adjustment). Errors and biases in the use of heuristics in medicine. ► Bayes' theorem and its applications in medicine. ► Clinical decision analysis. Decision trees. Advantages and limitations.
2	Clinical reasoning	► The process of clinical reasoning. Normative and descriptive theories. Analytic and non-analytic processes (pattern-recognition). ► Generation of diagnostic hypotheses. Differential diagnosis. Case specificity. ► Use and interpretation of diagnostic tests. ► Therapeutic reasoning. ► Cognitive errors in medicine. ► Standard clinical practice. ► The clinico-pathological exercise. ► Development of expertise. Deliberate practice. From novice to expert in medicine.
3	Clinical decision support with computer programs	► Overview of the systems and programs for decision support in medicine. ► Examples of programs: Iliad, DxPlain, ISABEL. ► Programs for patients' decision support.

BMI, biomedical informatics.

Figure 1 Appearance of the Moodle virtual learning environment in the biomedical informatics course.

Recruitment and faculty development of the BMI course professors was initiated, with each student group having a pair of teachers, one a clinician with expertise and/or experience in BMI, and the other a technical person who would complement the clinical teacher (information specialists, computer scientists, psychologists, information technology engineers). This teacher duo would provide students with a broader and deeper experience with the perspectives of a clinician and a more technologically oriented individual. For this initial stage we convoked clinicians with experience and courses in BMI, and asked them to take mandatory BMI faculty development workshops. The workshop had 10 h of face-to-face sessions and 20 h of online work, in which the potential teachers were immersed in the new curriculum and the BMI courses. They worked in small groups developing educational material for the courses, and were assessed when conducting an educational session, their online participation and a formal written test about the curriculum. All the professors passed the workshop, as they had the training and motivation to succeed in this preparatory stage.

Forty-six professors were hired by the Faculty of Medicine (24 physicians and 22 non-physicians) to implement the courses. The professors received two mandatory faculty development workshops as described above, as well as an online tutorial for using the Moodle platform. An online 'teachers' virtual room' was also designed for faculty communication, sharing of resources, and online discussion.

This was the first occasion that a curricular course in our undergraduate medical school program included a mandatory and formal e-learning experience, with the explicit expectation that students and teachers would use the virtual classroom for learning and assessment purposes. Five computer laboratory classrooms were built, with capacity to accommodate 200 students simultaneously. Our school is a public institution that is basically free for Mexican students, and a substantial proportion of them are of low or middle-class socioeconomic status. The new facilities were provided to the student population so all of them could have access to appropriate computer equipment and internet connectivity, because the courses were obligatory and there is no explicit institutional requirement that students have their own personal computer.

The first class of medical students took the BMI-1 course in the first academic semester of 2010, with a total of 1199 students in 32 groups of about 40 students each. We divided each group into six or seven small groups to promote team-based learning and used the virtual classroom tools for small group communication (chats, forums) in each session educational tasks. The BMI-2 course took place in the first academic semester of 2011.

There were two partial exams in each course that included two components: a multiple-choice question test with 70 items aimed at the application and problem-solving levels; and a practical hands-on test in the computer lab that explored competencies such as using Medline effectively, appraising the elements of a telemedicine consultation, among other things. These tests had summative and formative purposes, and at the end the students took a final summative test. This 70-item multiple-choice question exam had a reliability of 0.86 measured with Cronbach's α, a mean difficulty index p value of 0.67 and a mean point-biserial correlation index of 0.45. At the end of the BMI-1 program 97.3% of the student population passed the course. The average final grade obtained by averaging the exam score with the teacher's grade was 7.4 (on a scale of 10), with 45% of the students achieving a grade of 8 or above.

We applied a program evaluation anonymous survey to the students at the end of the course, a 41-item questionnaire that explored several aspects of the program. The instrument reliability measured with Cronbach's α was 0.93, and was returned by 1115 students (93% of the student population). The main results of the students' course evaluation are shown in table 3, the overall opinion of the students regarding the different elements of the program was good to excellent for educational activities, course resources and perception of clinical relevance.

This case report was considered exempt from institutional review board and written informed consent, because it describes

Table 3 Student evaluation of the BMI course at UNAM Faculty of Medicine (n=1115)

	Student answers				
Questionnaire items	**Very inadequate n (%)**	**Inadequate n (%)**	**Adequate n (%)**	**Very adequate n (%)**	**No answer n (%)**
The functioning of the computer equipment was	10 (0.9)	7 (0.6)	219 (19.6)	827 (74.2)	52 (4.7)
The functioning of the virtual classrooms was	6 (0.5)	14 (1.3)	289 (25.9)	750 (67.3)	56 (5)
The software programs used were	6 (0.5)	15 (1.3)	352 (31.6)	693 (62.2)	49 (4.4)
The design of the course sessions was	17 (1.5)	61 (5.5)	434 (38.9)	564 (50.6)	39 (3.5)
The audiovisual teaching material was	13 (1.2)	46 (4.1)	389 (34.9)	630 (56.5)	37 (3.3)
The online learning exercises were	25 (2.2)	88 (7.9)	489 (43.9)	483 (43.3)	30 (2.7)
The clinical cases used were	10 (0.9)	71 (6.4)	479 (43)	514 (46)	41 (3.7)
The number of participants in my subgroup was	18 (1.5)	54 (4.8)	413 (37)	589 (53)	41 (3.7)
The working performance of my subgroup was	41 (3.6)	92 (8.3)	430 (38.5)	517 (46.4)	35 (3.2)
The bibliographic material was	27 (2.4)	91 (8.2)	363 (32.5)	591 (53)	43 (3.9)
Having two teachers per group (a physician and an informatician) was	34 (3)	60 (5.4)	172 (15.4)	793 (71.1)	56 (5.1)
	Never n (%)	**Sometimes n (%)**	**Usually n (%)**	**Always n (%)**	**No answer n (%)**
Teachers made me reflect on how to apply this knowledge in my professional life	16 (1.4)	119 (10.7)	284 (25.5)	692 (62)	4 (0.4)
Critical appraisal of the teaching material was promoted by the teachers	24 (2.2)	139 (12.5)	396 (35.5)	551 (49.3)	5 (0.5)
The course made me reflect on its relationship with my other courses	61 (5.5)	243 (21.8)	394 (35.3)	414 (37.1)	3 (0.3)
Teachers promoted out of school study time	68 (6.1)	281 (25.2)	355 (31.8)	407 (36.5)	4 (0.4)
The course encouraged me to seek more information on the subject	102 (9.1)	337 (30.2)	364 (32.6)	309 (27.8)	3 (0.3)
In the face-to-face sessions we worked in small groups	36 (3.2)	111 (10)	316 (28.3)	646 (57.9)	6 (0.6)
Teachers gave me feedback on my verbal and written communication	173 (15.5)	272 (24.4)	285 (25.6)	375 (33.6)	10 (0.9)
Clinical medical terminology was incorporated in the course	27 (2.4)	116 (10.4)	281 (25.2)	687 (61.6)	4 (0.4)
The assignment papers were returned with feedback	152 (13.6)	262 (23.5)	274 (24.6)	418 (37.5)	9 (0.8)
The course promoted the development of skills and abilities	32 (2.9)	130 (11.7)	377 (33.8)	571 (51.1)	5 (0.5)
Clinical cases were used in class to cover the different themes	24 (2.2)	142 (12.7)	345 (30.9)	597 (53.6)	7 (0.6)
Teachers considered physician–patient relationship issues in class	25 (2.2)	104 (9.3)	309 (27.7)	673 (60.4)	4 (0.4)
Teachers pointed the importance of ethical issues in dealing with patients	20 (1.8)	58 (5.2)	276 (24.8)	755 (67.7)	6 (0.5)
Teachers noted the importance of ethical issues in informatics	19 (1.7)	89 (8)	278 (24.9)	724 (64.9)	5 (0.5)
Teachers included social context in the case discussions	32 (2.9)	140 (12.6)	387 (34.7)	551 (49.3)	5 (0.5)
Teachers pointed the importance of preventive actions in the cases	31 (2.8)	170 (15.2)	360 (32.3)	549 (49.2)	5 (0.5)
Teachers noted the frequency of the problems discussed in the course	38 (3.4)	172 (15.4)	413 (37)	488 (43.8)	4 (0.4)
Teachers promoted the development of professional values in the course	34 (3)	126 (11.3)	336 (30.1)	611 (54.9)	8 (0.7)
The course allowed me to reflect on my personal attitudes to technology	53 (4.8)	182 (16.3)	341 (30.6)	527 (47.2)	12 (1.1)
	Very easy n (%)	**Easy n (%)**	**Difficult n (%)**	**Very difficult n (%)**	**No answer n (%)**
The level of difficulty of the biomedical informatics course was	61 (5.5)	659 (59.1)	348 (31.2)	39 (3.5)	8 (0.7)
	Unsatisfied n (%)	**Little satisfied n (%)**	**Satisfied n (%)**	**Very satisfied n (%)**	**No answer n (%)**
My expectations of the biomedical informatics course were	52 (4.7)	222 (19.9)	618 (55.4)	217 (19.4)	6 (0.6)
	Insufficient n (%)	**Sufficient n (%)**	**Good n (%)**	**Excellent n (%)**	**No answer n (%)**
The knowledge and skills I acquired on the biomedical informatics course were	42 (3.8)	252 (22.6)	567 (50.9)	241 (21.5)	13 (1.2)
	Laptop n (%)		**Desktop PC n (%)**		**No answer n (%)**
The type of computer equipment that I would prefer to use in the classroom is	214 (19.2)		873 (78.3)		28 (2.5)

BMI, biomedical informatics.

the curriculum development and implementation data that was done as part of our program evaluation and quality improvement efforts. It explores data from students and faculty only in aggregate and anonymous form.

DISCUSSION

Major curricular change is a complex challenge in traditional and conservative medical schools. It requires long-term vision, participative leadership, innovative teamwork strategies, and a diffusion of innovations conceptual framework to increase the chance of success in the intricate systems of modern universities.[7] BMI is a discipline that needs space (real, virtual and cultural) in medical school curricula, to provide this basic competency for healthcare providers. The planning and implementation of our new medical school curriculum, including its BMI component, was designed following Kotter's eight steps for organizational change, starting with the establishment of a sense of urgency and followed by the other steps recommended to transform an organization (eg, forming a guiding coalition).[16] The curricular reform succeeded in terms of institutional approval, the creation of a new BMI academic department, the allocation of resources to build the computer laboratory facilities and to hire the required faculty, and the effective implementation in this first version of the BMI informatics course.

The fact that explicit time and credits were defined in the curriculum was pivotal to the implementation of the BMI courses. In organizational structure and culture the inclusion of mandatory courses sends the clear message that BMI is an important discipline, and legitimizes it in the eyes of the academic community, faculty and students. The new BMI courses include formal summative tests, which have to be passed in order to advance in the MD program. Assessment drives and promotes learning, which can have a significant effect on motivation and study strategies.

An aspect that is indispensable for successful course implementation is faculty recruitment and faculty development strategies. There are few BMI scholars in our country, so for this initial stage we identified local medical informatics 'champions' in hospitals and academic centers. The model of using a dyad of teachers per group (clinician plus non-physician) worked fairly well, because they complemented each other in terms of knowledge and skills about the technical matters of the discipline and its clinical implications for practice.

Another lesson is that we need to recruit academicians to obtain advanced degrees in the discipline, in order to be recognized as a true academic department on equal footing with the other traditional and larger departments.[17] The inadequate supply of persons with expertise in BMI is a problem in developed and developing countries, although the problem can be more acute in resource-limited environments.[6 18]

There are several published reports of BMI educational interventions in postgraduate medical specialty programs,[19 20] and a few in undergraduate medical students.[13 21 22] Many of them focus on the teaching of evidence-based medicine or online database searching,[3 23] but very few cover the broad aspects of the BMI field as we did in our program or have as many curricular hours devoted to the subject.[24] The education of only the 'practical' aspects of BMI like Medline searching provides a fragmented and limited view of the richness of the discipline, and it is our opinion and that of other authors that medical professionals should be exposed to the whole spectrum of BMI-relevant concepts in a formal and integrated fashion in medical school.[5] It is very likely that the situation will change in the short term, after the approval of clinical informatics as a medical subspecialty by the American Board of Medical Specialties in September 2011.[25]

We found almost no published reports of BMI educational initiatives in medical students in developing countries in the peer-reviewed literature.[26] Browsing the websites of medical schools in Latin America we identified several that have a course or elective on BMI, but have scant information about the details of the curricula (themes, credits, hours, educational models, etc) or program evaluation. The educational challenges of medical schools and academic health centers need to be viewed from the local and global perspectives and, even though resource-limited settings can have specific financial issues, we are convinced that key lessons can be gleaned from our experience that are relevant to individuals and institutions that want to promote BMI education in their settings (box 1). In order to effect organizational change, these lessons need to take into account the local symbolic, political, human resources and structural frames of the parent organization, its cultural and organizational aspects, and the so-called 'hidden curriculum'.[7 9 27]

Our work has some limitations: it is the experience of a single public medical school in Mexico, which can limit the generalizability of the findings to other settings; it describes the initial BMI courses in the first year of the new curriculum implementation, which was accompanied by an intense effort that can overestimate the educational impact of the BMI course; the implementation of discrete separate BMI courses could limit the integration with other courses.

We are convinced that the initiation of formal BMI training in our medical school is an important step in the right direction, which we speculate will produce an 'educational domino effect' in our country's medical schools, as many of them follow UNAM Faculty of Medicine in terms of curricular changes. This case report describes strategies that could be used to circumvent the organizational obstacles that a BMI educational intervention can encounter, providing an example of an initially successful curricular change including BMI in the training of medical students.

We argue that BMI is an essential component of quality medical care in the current era, and that medical schools and healthcare systems should strive to achieve effective academic and educational BMI programs in universities, government and academic health centers, as several authors have proposed.[5 21 28] BMI courses should include the modern conceptual frameworks of the discipline, and promote the translational research needed to go beyond data and information to knowledge and clinical wisdom, with effective use of decision making and clinical reasoning in complex environments.[4 24 28 29] The dissemination of the current BMI model in the educational and healthcare setting needs to be accompanied by an explicit and continuous concerted effort in order to have a positive impact in all the involved parties, clinicians and teachers of other courses need to be cognizant of the modern concepts of BMI and their relevance to the training of healthcare professionals.[30–32] The challenge of teaching BMI in medical schools is both difficult and exciting,

Box 1 Lessons learned relevant to BMI education initiatives

- Distinguish computer skills from BMI competencies.
- Use a formal curricular design model to plan, implement and assess the educational intervention.
- Develop educational materials integrated with the rest of the educational framework.
- Design faculty development activities targeted to the intervention, as practical as possible and mandatory if feasible.
- Balanced and dynamic use of blended-learning, using face-to-face and online activities as dictated by educational goals and practical constraints.
- Make sure that content is relevant to clinical and real-life scenarios, in which BMI competencies can be potentially inserted in most medical activities.
- Include BMI in summative assessments and make educational activities count.
- Strive for a balance in maintaining BMI as an exciting individual discipline, as well as a multidimensional network of linked sciences relevant to medicine.
- Include practicing clinicians in all the steps of the educational process.
- Convince non-BMI faculty in the medical school and healthcare centers that BMI is relevant to their practice.
- Identify BMI local 'champions' and recruit them for teaching.
- Augment the number of clinicians with postgraduate formal training in BMI, and develop interdisciplinary teaching teams.
- Consider structural, political, symbolic and human resources frames, and strive to integrate them.

and the effective use of information technology is indispensable for 21st century physicians.

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Contributors MSM and AIMF developed the concept of the paper. All the authors developed the BMI curriculum as a task force group. ARV and JVC designed, developed and implemented the online platform for the course. MSM and AIMF did the literature search and wrote the first draft of the paper. All authors contributed to data collection and the final manuscript draft.

Competing interests None.

Ethics approval This paper is not a hypothesis-driven research study, it is a descriptive curriculum development and evaluation report, which is part of the implementation of our faculty of medicine 2010 program. Therefore it constitutes a portion of the educational program quality assurance activities, which were approved by the Technical Council of the Faculty of Medicine and the appropriate governing bodies of our university. Appropriate care was taken for data management and student confidentiality, all data are aggregate without individual identifiers.

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