Role and Impact of Bibliometric Analysis of Research Productivity in Faculty Evaluation, Recruitment, Promotion, Reappointment, Benchmarking, and in Mission-Based Management (MBM): Experience of the Faculty of Medicine at the American University of Beirut (AUB), 1997–2007

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Abstract The use of bibliometrics in research evaluation is rapidly gaining popularity and importance. It is becoming an essential tool to assess and stimulate research productivity, guide decisions in research funding and benchmark with peer institutions.

This chapter focuses on bibliometric analysis of research performance in the Faculty of Medicine (FM) at the American University of Beirut (AUB). Data are obtained from the Curriculum Vitae and the databases of Scopus and ISI Web of Science. Performance of the FM is compared to similar data obtained from 1997 to 2007 for 123 medical schools registered at the American Association of Medical Colleges (AAMC). The indicators applied include: number of papers, total number of citations, average citations per paper, percentile journal ranking per discipline, impact factor (IF), Adjusted IF (Adjusted IF is the Journal Impact Factor (IF) adjusted for the type of publication and author position of each investigator), impact index, and funding. Collaboration patterns within and among the departments at the FM are presented.

The targets established for FM can be partially attributed to increasing, as per Scopus, the number of articles by 4.7-fold, the number of articles per faculty per year by 4.0-fold, and extramural funding by 3.7-fold, in 10 years. This improved the

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quality of research productivity at promotion without decreasing promotion success rate, and increased the number of faculty members eligible for tenure or long-term contract. The average amount of funding required at FM per investigator to achieve the set target is determined.

Applying a basket of bibliometric indicators provides an overview of the research productivity of the investigator, department and medical school. Bibliometrics complement rather than replace peer assessment, they guide decision-making and facilitate benchmarking.

Keywords American University of Beirut (AUB) · Bibliometrics · Benchmarking · Faculty of Medicine · Faculty evaluation · Research Funding · Promotion · Research productivity · Research evaluation · Collaboration

1 Background

The Faculty of Medicine at the American University of Beirut (AUB FM) was established in 1867 and built its hospital complex in 1908–1910. Schools of Nursing, Pharmacy, and Dentistry were added from 1871 to 1910. The School of Public Health was established in 1954. The complex was developed similar to that of peer institution in the USA. Residency programs started in 1945 and specialty fellowship programs began as of 1971. The hospital was the first in the region to receive full accreditation by the US Joint Commission on Accreditation of Healthcare Organizations, JCAHO (1956–1986).[1] It became a referral center for patients from the entire region and beyond. A new Medical Center (AUBMC) with a 425-bed hospital was inaugurated in 1970. In addition to the medical program leading to an MD degree and a graduate program in basic sciences leading to an MS degree, a PhD program in basic medical sciences was established in 1966. A laboratory research and teaching building, the Diana Tamari Sabbagh Building, was occupied by the FM in 1975.

The Lebanese civil war from 1975 to 1991 interrupted and changed the course of progress at the Medical Institutions (MI) of AUB. The patient pool diminished significantly to become primarily that of west Beirut. The patient mix became skewed to that of a war zone. The Medical Center, however, adapted quickly to war and took care of almost all the serious victims in most of Lebanon. Faculty attrition occurred gradually and peaked in 1984–1991 while the student catchment area became restricted almost to Lebanon. Faculty and administration succeeded in maintaining excellence in medical education and postgraduate training at the cost of consolidation. The PhD program was suspended in 1987 after the last student graduated. Tenure appointment was suspended in 1985. The number of full-time basic science faculty members went down to 10. They continued to give all medical courses in

[1] Renamed Joint commission (JC) in 2007 and established the Joint Commission International (JCI) for international institutions.

basic sciences with contributions from clinical and visiting faculty, but eliminated to a great extent laboratory and discussion sessions. Teaching became didactic and modular. Graduates continued to excel in the US or elsewhere similar to their predecessors. Patient care was affected most. The rapid change in the catchment pool, patient load, and mix, made some services downsize while others, such as orthopedic surgery, grow rapidly. The number of occupied beds gradually decreased from around 400 to approximately 170, with hospital floors having to be closed. This resulted in maldistribution of hospital employees, whose total number also became relatively large, a number of employees however, could not show to work regularly because of hostilities. Significant variations, discrepancies, and inequity in remunerations of faculty members/physicians and employees of equivalent status, resulted from the stepwise and profound devaluation of the Lebanese pound (1984–1993) inspite of variable attempts for re-adjustments. During this period, the hospital was reimbursed through Government (National Social Security Fund, NSSF and Ministry of Health, MOH) funds, direct contributions or indirect through warring factions, non-government organizations (NGOs), and self-pay. After the fighting stopped in 1991, contributions gradually decreased and within few years, NSSF and MOH funds started to deplete. As of the late 1990s, the rate of increase in expenses became higher than the rate of growth in revenues, with significant uncollectable government receivables. The recovery from this unsustainable structural deficit required preparing the grounds for attracting and recruiting highly credentialed faculty members, including academic physicians to grow the required balance of services that would attract privately insured and self-pay patients. Success in research is a major determinant of academic mobility to the US and globally. An environment that allows and supports achievement of the desired research outcome at AUB is a strict requirement of serious candidates contemplating to apply for appointment at AUB in Lebanon. It keeps all options of mobility open. This chapter focuses on the role and impact of bibliometric indicators, particularly in research, on transforming the prevailing steady state and culture to that of dynamic change by succeeding to recruit skilled change agents in a planned manner. Bibliometric analysis also enhances the transparency and expectations for promotion, career development, and acquisition of a long term (7 years at AUB) or tenure appointment (re-established at AUB in 2017).

The Medical Institutions at AUB needed major restructuring to move away from a consolidated status quo that became unsustainable, and to engage in a process of sustainable growth that puts them at par with peer institutions in the USA. This chapter also focuses on the role and impact of bibliometrics on building a growth-oriented research enterprise, in particular monitoring the rate of growth and achievement of targets set internally as well as benchmarking with peer institutions externally.

The mission statements of FM and the AUBMC included "… to participate in the advancement of knowledge through research … Chartered in New York State in 1863, the university bases its educational philosophy, standards, and practices on the American liberal arts model of higher education." In looking for a research vision for the future, the general recommendations from inputs of a large base of intramural and extramural stakeholders are summarized in Fig. 1. It was estimated

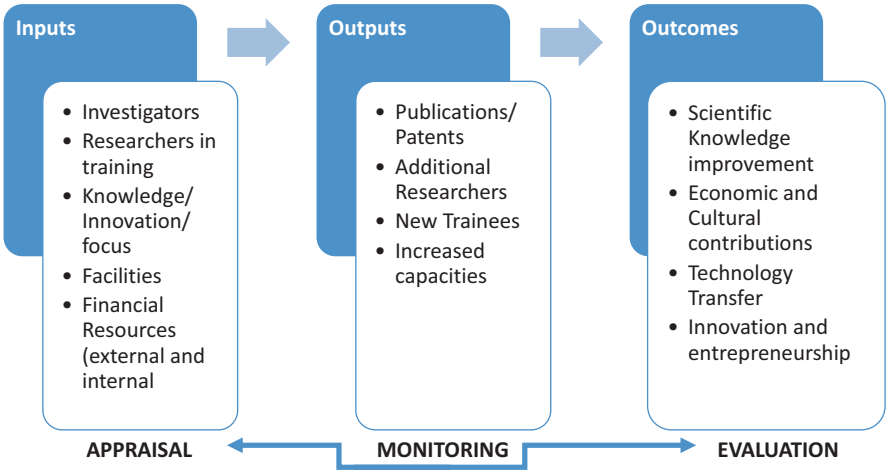


Fig. 1 Critical mass of inputs needed to generate the defined outputs and achieve the desired outcomes

that about 400+ full time equivalents (FTEs) of faculty members/academic physicians were needed within 20 years to fulfill the mission, revive the Medical Center by rightsizing all services, strengthen and financially sustain the teaching, research, and clinical demands of the FM and Medical Center. The rate of their recruitment would parallel equipping and growing the Medical Center, including the opening of hospital beds, going up from 170 beds occupied in 1999 to a target of 425, and upgrading the associated services and facility to support the academic and patient-care programs required to achieve fiscal balance and sustainable growth.

To pave the way for expanding the research enterprise, seven core research facilities, open to all investigators in the university, were established by 1999 within a newly established Program of Cellular and Molecular Medicine in the FM, parts of which were operational as of 1997. The facilities include: core laboratories in molecular biology, protein chemistry, imaging and confocal microscopy, patch clamp, environment/analytical chemistry, radioactivity work stations with autoradiography, bioinformatics facility, as well as a modern animal-care facility ready for transgenic mice studies. The required human infrastructure for all, including that for an Institutional Review Board (IRB) and an Institutional Animal Care and Use Committee (IACUC) were concomitantly established. The objectives of the core facilities are: (a) to make available to all researchers at AUB, expensive and frequently needed multipurpose equipment; (b) train research scientists for each facility who, with the help of biomedical engineering, set up, operate, and maintain such equipment/facility and make them available to investigators with reasonable cost, waiting time, and provide them with the necessary support and training; (c) insure the availability of supplies that can be purchased by investigators without the long delay required for orders to come from abroad; (d) diminish markedly the set-up time (down-time) for new recruits, which is extremely important in attracting active

researchers with ongoing projects, to come to AUB in Beirut, Lebanon; (e) enable investigators to produce research that attracts competitive external funding; and (f) develop a critical mass of about 15 established investigators with adequate funding to re-establish the PhD program in biomedical sciences.

Sources of financial support to realize the various aspects of the mission in any university, include primarily revenues from: student tuitions, hospital and patient care, research funding, patents, return from university endowments restricted to the FM/AUBMC, donations and government subsidies, if any, to the FM/AUBMC, and share of FM/AUBMC from unrestricted university endowments and donations. Competition for the limited resources for the various aspects of the FM/AUBMC mission and among the different academic units of the university necessitates the development of clear plans with measurable indicators including metrics for quantity, quality and value, as tools to guide the decision-making process. Decisions, particularly in Lebanon and the Arab countries that have been passing through profound cycles of shifting steady states throughout the past century, cannot be made on an historical basis. The rapid pace of breakthroughs in technology and discoveries in the last half a century made this problem, albeit for a different reason, not unique for the region. The Association of American Medical Colleges (AAMC), in 1998, formed a task force that came out with recommendations for a Mission-Based Management (MBM) approach [1, 2]. Effort and money are to be matched, albeit with great difficulty, to an academic medical center's three traditional missions of education, research, and clinical care. Decisions regarding departmental support by the dean can then be made on a mission-directed rather than on historical basis [3]. In addition to time effort analysis within the traditional missions of teaching, research, clinical care, and administration, MBM includes assessment of productivity and value of each activity with its associated cost. MBM provides a tool for medical centers to optimize the alignment of institutional resources with both the existing activities of the faculty and new strategic initiatives. A number of papers discussed various approaches for the redistribution of resources based on the quantity and quality of faculty effort [3–7], provided that the obtained metrics and data, derived from actual contributions, are validated. A metric system is an important tool which, if carefully devised and properly understood, would greatly assist department chairs and deans in investing institutional resources wisely and helping them set clear targets and goals. It could also help in decision-making regarding promotion and tenure as well as accurate costing and right-sizing of faculty [8]. A literature review done in 2005 revealed that institutions in the United States predominantly used research grant levels, particularly NIH grants, as the primary benchmark to evaluate research faculty and to allocate resources, whereas European institutions use publication bibliometric data, specifically, the impact factor of the journals in which the faculty members publish [9–12]. As such, and in the absence of an NIH-like peer system in Lebanon and the region, it became important that FM/AUBMC develop policy guidelines and a metrics system that would allow it to measure and reward faculty effort in research, teaching, patient care and administration. In this chapter, the role and impact of bibliometric analysis of research productivity on faculty evaluation, recruitment, promotion, tenure appointment, rate of growth, MBM, and benchmarking are considered for the period from 1999 to 2009.

2 Tools, Process, and Methodology

2.1 Setting the Stage

Two committees were established. (i) The Research Committee to create a system for allocating intramural research funds and acting as a grant office, and reviewing all extramural grant applications. The detailed research-proposal application form had to be adhered to with clear justification of the budget. Each application had to be cleared by the Institutional Research Board, the Institutional Animal Care and Use Committee for animal use, and reviewed by three peers. Decisions for funding were made in two cycles per year. Funding was awarded in descending order of scores; the number of proposals funded depended on the budget for that cycle. Intramural funding came primarily from the University Research Board's (URB) allocations to Medicine, the Diana Tamari Fund endowment for basic sciences until 2001, and the Deans Research Fund. As of 2003, the largest portion came from the research fund of the Medical Practice Plan. Extramural funding initially came from the Lebanese Research Council but significantly increased through competitive external funding from diverse sources; for amounts from 1998 to 2008, see Table 8. (ii) The Core Facility Committee, formed by the chairs of the users' committees for each facility, was charged with oversight, writing policies and procedures for the use of each facility including developing a process for research space allocation, timely receipt of supplies, and determining the mean wet-research-bench cost per month for various disciplines.

2.2 Bibliometrics

Both committees recommended in 1996–1997 the introduction of bibliometric assessments to compliment the traditional peer-review process. Bibliometrics as defined by Tague-Sutcliffe in 1992 [13] "is the study of the quantitative aspects of production, dissemination and use of recorded information and the development of mathematical models and measures for these processes that are efficiently produced and are useful for prediction and decision making". The performance bibliometric indicators recommended included four components (a) publication frequency; (b) citation analysis [13–15] which included total citations of all the publications of an investigator, citations for each article and the average annual citations and per article, percent of self-citations, and articles with zero citations. Citation per paper measures impact with respect to output. Different fields of research may differ multiple folds in the rate of citations and hence comparisons should be strictly like for like [16–18] i.e. within the same discipline. Uncited articles reflect those with little or no impact. (c) Journal impact factor (IF) calculated by dividing the number of citations a journal receives for all articles published in the two preceding years by the number of articles published in the journal in the same period [19, 20] and

Table 1 Relative weights for adjustments by type of publication and by position of author

Adjustments by type of publication	Weight	Adjustments by authorship position	Weight
Original research	1	First/senior	1
Review/editorial	0.75	2nd author	0.5
Case report	0.50	3rd author	0.25
Letter	0.25	>=4th author	0.15

measures the impact of the Journal. In its calculation, original papers, case reports, reviews, editorial, and letters are considered equivalent publications. The two FM committees hence adjusted the Journal IF for each investigator using a weight ratio for the type of article; original articles; reviews/editorials; case reports; letters, as 1.0:0.75:0.5:0.25 and for authorship position; first/senior: 2nd: 3rd: >=4th as 1:0.5:0.25:0.15, as illustrated in Table 1. In this chapter, the IF was dubbed "crude" IF and the latter, "adjusted" IF. The "crude" IFs of journals in each discipline determine the percentile rank of a journal in that discipline, allowing for analyzing the investigator's publications within their discipline. (d) H-index, introduced by Hirsch in 2005, combines the number of articles published by an investigator with the number of citations, and is calculated as the first h (number of) articles that receive h citations or more [21]. This measure relates to the investigator. There are a number of derivatives for the H-index e.g. g-index, m-index and a-index [22] that were introduced later; each is introduced to attenuate a shortfall of the H-index or others. The "crude" IF for institutional assessment is limited by size dependency; the impact index was introduced to attenuate size dependency [5].

2.3 Building the Database

The curriculum vitae (CVs) of all faculty members, reaching 202 CVs from 19 departments[2] in 2007, were analyzed for the recommended bibliometric indicators, on an ongoing manner since 1997 by each department, with support from the Dean's office. A database consisting of 8212 publications, the oldest published in 1957 was built. Databases used included Institute for Scientific Information (ISI) web of science and Scopus for extracting all bibliometric data; statistical package for the social sciences (SPSS) for data analysis; Excel, Access for building the database, and Visual Basic (VB) for determining collaboration patterns. A faculty Profile Software Application[3] was built in-house as an integrated research information system with online data inputs, automatic notifications, real time analysis, and instant reports. The departments are responsible for updating the database through online

[2] The Emergency Department (ED) was established in 2004 and was not included in all data for this Chapter.

[3] Sami Cortas, Karam Rizk and Joe Max Wakim built the in-house software and packages of the Hospital Management and information Systems.

inputs by each faculty member. The process is currently significantly easier through advances in Scopus, ISI Web of Science, and Google Scholar, making online access very easy.

2.4 Evaluation of Education and Clinical Training

Education and clinical training is assessed by a commercial online set-up, MyEvaluations.com and MyGME, the latter for Graduate Medical Education.[4] The process includes filling online forms by students for instructor and course evaluations in both, basic sciences and the various clinical teaching activities. Online forms for peer evaluations in different activities are filled. MyEvaluation prompts by email individuals to fill the forms. Data are centrally compiled and analyzed, with capabilities of benchmarking. The FM also benefits from the AUB Office of Institutional Research and Assessment (OIRA) that uses an in-house-developed Instructor Course Evaluation (ICE) software for course, instructor, and outcome evaluations. OIRA purchased in 2014, Blue eXplorance, a Canadian software[5] for the same purpose and for 360° evaluation.

2.5 Clinical Workload Profile

The clinical workload profile for each faculty member was extracted from an in-house-built Hospital Management System, to which many modules were added from the 1990s through 2009. The system is updated automatically and regularly produces management reports including faculty workload profiles.

2.6 Faculty Effort Analysis

KPMG,[6] with the Dean's office, designed, prepared the forms and administered a process to determine the effort spent by each faculty member in teaching, research, clinical training, clinical service (patient care), academic administration, and clinical administration. After clearly explaining the purpose, process, and forms to the faculty in small groups and giving them time to fill them, the data were tabulated and analyzed for the effort and percentage of total effort spent in each activity. The

[4] MyEvaluations.com and MyGME, latter for Graduate Medical Education, are registered trademarks of MyEvaluations.com Inc. © 1998–2018. U.S. Patent #7, 899,702. All rights reserved.

[5] Blue eXplorance, Copyright 2018 © eXplorance Inc. All rights reserved.

[6] A professional service firm and one of the big four auditors worldwide. The name "KPMG" stands for "Klynveld Peat Marwick Goerdeler."

data were then entered and analyzed by a web-based software, built in-house as part of the Hospital Information System. The process was audited and the software validated by KPMG and the AUBMC IT team. On-line entry of the data and analysis thereafter on a yearly basis initiated building the database and producing annual reports.

3 Review of Databases, Relevance, and Outcome

The different databases, built and used as of 1997, are analyzed to define conditions at a point in time and monitor change. They are used as such, or in different combinations thereof as key indicators to determine progress towards targets and goals. Collectively, they act as a statement of conditions at a certain point in time. Means, medians, and standard deviations define where an individual stands relative to peers in each particular indicator, earmarking personal strengths, weaknesses, opportunities, and threats while defining relevant (irrelevant) indicators for that person for the future. Faculty portfolios, to a significant degree, are automatically updated and serve in the process of ongoing faculty self-evaluation and periodic evaluation for contract renewal, promotion and career planning.

3.1 Bibliometric Database and Selected Reports

The report shown in Table 2 is a sample report of a selection of bibliometric indicators of faculty members in the rank of associate professor and professor in the department of Anesthesiology (AUBMC), the name of the faculty member is represented as a number. The total active years of research start from the first publication till the desired date, in this case 2007. The means and standard deviations for each of the parameters, with rank and seniority, defines the characteristics of the group and make it easier to set goals and targets for improvement through promotion and recruitment.

In comparing departmental averages for “crude” IF and “adjusted” IF with total publications in each department, shown in Table 3, it became apparent that each discipline has its characteristics with respect to bibliometric indicators. This is in agreement with observations in the literature [16–18]. Comparisons are thus made with peers in the same discipline locally and, by benchmarking, internationally. The latter was very difficult to obtain when the data collection started since determining the benchmark sample and calculating or extracting the parameters was labor intensive and difficult in 1997. Now, it is easily available on a number of accessible web-based services such as the ISI web of science, Scopus, and Google scholar.

The different types of publication(s), defined as original, review, case report, or editorial, for each investigator was included in Table 3 along with a chosen basket

Table 2 Bibliometric profile of faculty members in the rank of associate professor and professor in a given academic department for the period from the first paper published by each till 2007 (shown here for Anesthesiology), with the mean and SD for each group

Faculty in the Anesthesiology Department	Rank	Date of 1st publication	Total years	Total publications	IF crude/ year (all years)	IF adjusted/ year (all years)	Total citations	Average annual citations	Total citations/ paper	H-index
1	Associate Professor	1994	13	**43**	6.2	2.9	**194**	15	4.5	**7**
2	Associate Professor	1985	22	**30**	2.1	1.0	**264**	12	8.8	**4**
3	Associate Professor	1994	13	**26**	5.6	3.1	**315**	24	12.1	**8**
4	Associate Professor	1989	18	**11**	3.5	1.3	**200**	11	18.2	**3**
5	Associate Professor	1989	18	**12**	1.0	0.2	**81**	5	6.8	**3**
6	Associate Professor	1988	19	**46**	2.0	0.4	**61**	3	1.3	**10**
7	Associate Professor	1991	16	**42**	7.2	3.6	**284**	18	6.8	**11**
8	Associate Professor	1982	25	**35**	1.2	0.3	**27**	1	0.8	**7**

9	Professor	1970	37	**477**	1.2	0.2	**53**	1	0.1	**18**
10	Professor	2000	7	**32**	4.3	8.0	**18**	3	0.6	**10**
11	Professor	1991	16	**57**	4.2	2.1	**307**	19	5.4	**8**
12	Professor	1987	20	**25**	1.9	0.5	**333**	17	13.3	**3**
	Mean Associate Professor		18	**31**	3.6	1.6	**178.3**	11.1	7.4	**6.6**
	SD Associate Professor		4	**14**	2.4	1.4	**109.6**	7.9	5.7	**3.1**
	Mean Professor		20	**148**	2.9	2.7	**177.8**	10.0	4.8	**9.8**
	SD Professor		13	**220**	1.6	3.6	**165.2**	9.3	6.1	**6.2**

Table 3 Bibliometric profile of each academic department in the Faculty of Medicine from 1997 to 2007 reflecting crude IF and adjusted IF, both per year, the total publications and the total number of original papers and those on which the author is a senior author. Total citations and those for the original articles with the particular investigator as senior

Department average	IF crude/ year	IF adjusted/ year	Total publications	Original	Original and senior	Total citations	Citations (original and senior)	H-index
Anesthesiology	4.7	2.1	**27.4**	12.9	6	**278**	30	**7**
Biochemistry	15.3	8.1	**26.5**	25.3	9.3	**1039**	398	**19**
Dermatology	1	0.4	**6.5**	0.9	0	**106**	16	**5**
Diagnostic Radiology	4.4	1.4	**28.6**	10	2.9	**204**	50	**5**
Emergency Medicine	0.4	0.2	**5.3**	2	1	**14**	0	**1**
Family Medicine	1.5	0.9	**9.5**	6.1	2.6	**28**	6	**2**
Human Morphology	10.1	6	**34**	30.8	16.6	**431**	151	**10**
Internal Medicine	10.4	5.5	**30.9**	16.5	8.3	**539**	199	**9**
Microbiology and Immunology	3.6	2.4	**26.7**	23	18	**281**	116	**6**
Obstetrics and Gynecology	5	2.6	**27.5**	14.3	8.1	**269**	108	**8**
Ophthalmology	6	3.6	**35.2**	20.5	12.7	**245**	116	**8**
Otolaryngology	2.2	1.2	**23.4**	11.9	9.4	**129**	59	**7**
Pathology and Lab Medicine	4.8	1.8	**24.8**	14.6	5.3	**227**	70	**6**
Pediatrics	7.6	3.9	**21.9**	15.6	7.6	**551**	162	**8**
Pharmacology	1.7	1.3	**6.3**	6	4	**115**	23	**6**
Physiology	9	6	**21**	20.5	11.3	**430**	133	**9**
Psychiatry	4.8	3.3	**9**	7.3	2.7	**192**	178	**4**
Surgery	2	1	**15.1**	11.1	5.2	**122**	37	**5**
Average	5	3	**21**	14	7	**289**	103	**7**
SD	4	2	**10**	8	5	**245**	97	**4**

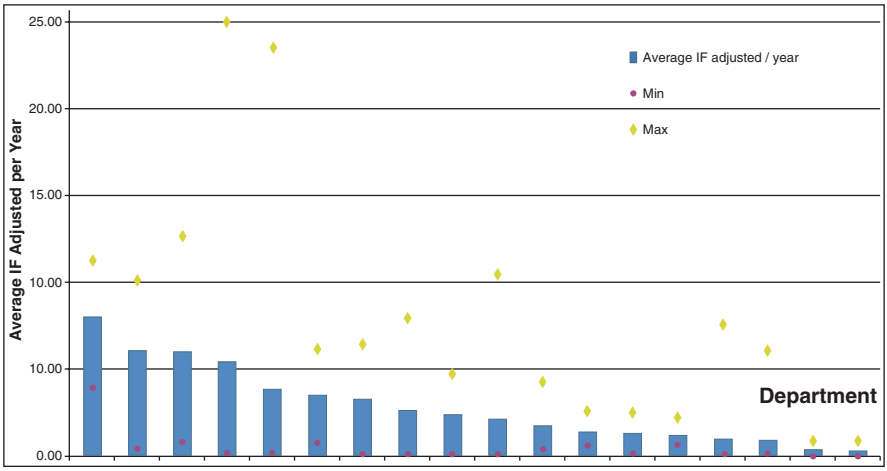
of bibliometric indicators. Most articles in the biomedical literature are multi-authored. Usually the senior author is either listed the first or last. In the latter situation, the first author would have contributed significantly to developing methodology and performing bench/ground work while the senior author, in addition, would have developed the research proposal, obtained funding, and normally the work is done in space allocated by the institution to the senior investigator. Each of the other listed names would have contributed variably to the work. The Research Committee conducted a survey and recommended that different weights be given to the type of publication and position of the investigator in the author's list as presented in Sect. 2.2. The bibliometric indicators available in 1997 included citation analysis, the Journal IF, and the ranking of Journals by IF in each discipline. The "adjusted" IF was an attempt to customize the "crude" IF to the investigator's publications while realizing that the "crude" Journal IF is an average of all articles in the journal. The H-index and its derivatives were introduced as of 2005 and beyond.

The process of creating a bibliometric database started initially by analyzing the curriculum vitae (CV) of each faculty member. The IF of journals in which each article is published was obtained from ISI web of science and later Scopus. The sum of IFs for journals of all articles in a CV is considered as the "crude" IF of the faculty member. The list of publications was then analyzed for the type of publications and the position of the author. The "adjusted" IF is calculated as described in Sect. 2.2. The sum "adjusted" IF was calculated for each investigator. The mean "adjusted" IF for each department is computed and shown in Table 4 with the minimum and maximum for each department. The differences between departments were not only related to differences in discipline but also to funding, proportion of active researchers, total number of faculty members, particularly in smaller departments with higher teaching or clinical workload per faculty member.

3.2 Collaboration Patterns

Collaboration within the institution resulted in higher and more comprehensive multidisciplinary productivity. Collaboration with international investigators, studied for the years 1991–2001 resulted in more original publications than work done at AUB only (65% vs 35%, $p < 0.001$, and a higher "crude" journal IF for the publications 3.20 ± 3.85 vs 1.71 ± 2.36, $p < 0.05$ [23]. Software built in-house generates a matrix of the number of papers written in intra- or inter-departmental collaboration at FM as shown in Table 5. The software can be used to map collaborations with international investigators. The caption for Table 5 is self-explanatory.

Table 4 Mean adjusted IF on the vertical axis, shown as bars for each department and represented on the horizontal axis from highest to lowest. The minimum for each department is shown by "red dots" and the maximum by "yellow diamonds." The names of the departments are withheld to avoid biased interpretation (see text)



3.3 *Faculty Research Profile*

A faculty research profile was drafted as shown in Fig. 2 and updated on a yearly basis. The bibliometric indicators were used to monitor trends, set goals and targets. "Crude" IF and other bibliometric indicators are among the determinants of competitive funding from Europe. The faculty research profile shows at a glance, the total number of articles published by each faculty member, the number published since last contract or promotion, the number of papers in which the investigator was the first or senior author (Fig. 2), the number of each type of publication, with S next to the number of articles in which the investigator was the senior author, the total "crude" and "adjusted" IFs and each shown per year, total citations and annual citation rate, H index, and the number of articles and types, published in journals above the 75th percentile, between the 50th and 75th percentile, and below the 50th percentile in discipline.

The H-index was introduced in 2005 [21] and its computation was added to the research database. The H-index was correlated with the number of publications, total citations, and "adjusted" IF in 2008, for faculty members at FM/AUBMC with H-index above 15 as shown in Table 6. The mean ± SD for the 17 faculty members for number of publications is 52 ± 28; for total citations is 1676 ± 1606; for "adjusted" IF is 10.13 ± 5.11, and for H-index is 20 ± 8. Pearson's r-value for correlation of H-index with number of papers is 0.181 (NS), with citations is 0.978 ($p < 0.0001$), and with adjusted impact factor is 0.474 ($p < 0.001$). This supports our use of the "adjusted" IF as a bibliometric indicator for research productivity at the FM.

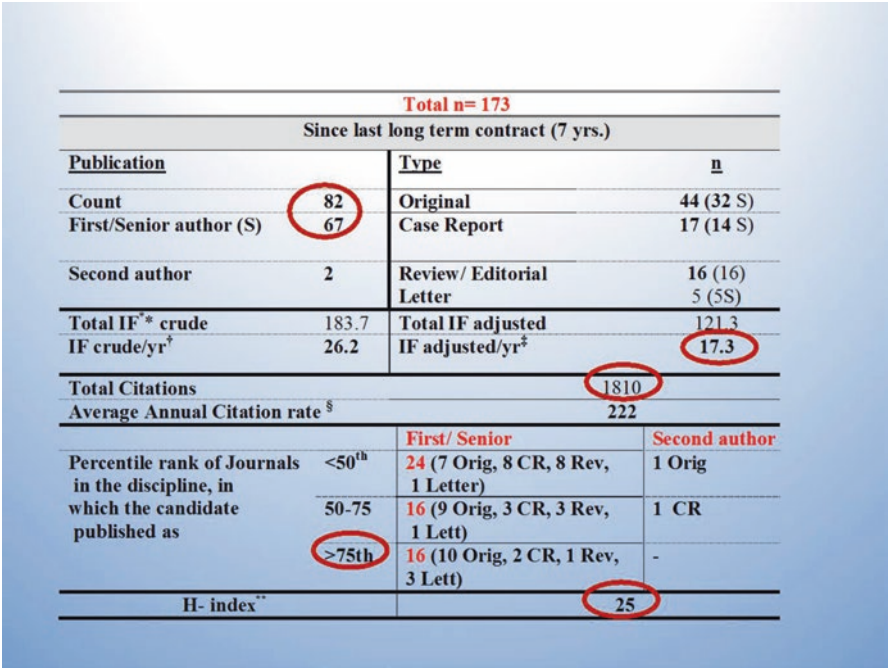
Table 5 Intra- and inter-collaboration matrix within and across departments in the FM/AUBMC. All departments are listed alphabetically on both, the horizontal and vertical axes. The number of papers at the intersection of column for one department and the row of the other indicates the number of article done in collaboration by the two departments. The darker the intensity of the color in each square, the higher the collaboration

	Anesthesia	Biochemistry	Dermatology	Diagnostic Radiology	Family Medicine	Human Morphology	Internal Medicine	Microbiology	ObGYn	Ophthalmology	Otolaryngology	Pathology & lab Medicine	Pediatrics	Pharmacology	Physiology	Psychiatry	Radiation Oncology	Surgery
Anesthesia	236						1		1	1	7	1	2					12
Biochemistry		2				2	3						6	1	1			
Dermatology			23			2	5		2		1	1	1					1
Diagnostic Radiology				77	1		18		4	2	2	13	4			1		12
Family Medicine				1	29		2		1		1	5	7	1		1		2
Human Morphology		2	2			16	32		1			4	17		39	5		6
Internal Medicine	1	3	5	18	2	32	234		41	5	2	40	18	4	15	3	2	37
Microbiology								10			2	1	1					2
ObGYn	1		2	4	1	1	41		211	3		9	9				1	6
Ophthalmology	1			2			5		3	151			1					1
Otolaryngology	7		1	2	1		2	2			33	13	2					4
Pathology & lab Medicine	1		1	13	5	4	40	1	9		13	28	12	1	1			19
Pediatrics	2	6	1	4	7	17	18	1	9	1	2	12	103	1	4	1		21
Pharmacology		1			1		4					1	1					
Physiology		1				39	15					1	4			4		6
Psychiatry				1	1	5	3						1		4	6		1
Radiation Oncology							2		1									1
Surgery	12		1	12	2	6	37	2	6	1	4	19	21		6	1	1	119

3.4 Lessons from Benchmarking

In 2008, Dean Hendrix published an article entitled, "An analysis of bibliometric indicators, National Institute of Health funding, faculty size at the Association of American Medical Colleges (AAMC) medical schools, 1997–2007" [24]. The same parameters were obtained for FM/AUBMC for the same period. The means, SD, and coefficient of variance of the collected and synthesized bibliometric indicators reported, in addition to NIH funding and faculty size for the 123 AAMC registered medical schools, taken from Table 3 of Hendrix's publication [24] are shown here in rows 2–5 of Table 7, alongside data from FM/AUBMC in the bottom row.

The FM/AUBMC fits within the distributions of all the size-independent parameters reported for the USA schools, although the data were collected for FM/AUBMC, a decade after emerging from war, during which teaching and service loads per faculty were very high while research facility and funding were limited. A



Total n= 173			
Since last long term contract (7 yrs.)			
Publication		**Type**	**n**
Count	82	Original	44 (32 S)
First/Senior author (S)	67	Case Report	17 (14 S)
Second author	2	Review/ Editorial	16 (16)
		Letter	5 (5S)
Total IF* crude	183.7	Total IF adjusted	121.3
IF crude/yr†	26.2	IF adjusted/yr‡	17.3
Total Citations		1810	
Average Annual Citation rate §		222	
		First/ Senior	Second author
Percentile rank of Journals in the discipline, in which the candidate published as	<50th	24 (7 Orig, 8 CR, 8 Rev, 1 Letter)	1 Orig
	50-75	16 (9 Orig, 3 CR, 3 Rev, 1 Lett)	1 CR
	>75th	16 (10 Orig, 2 CR, 1 Rev, 3 Lett)	-
H- index**		25	

Fig. 2 Sample of a faculty research profile with the total number of papers published to date shown on top center e.g. n = 173. Data since the last contract or promotion are entered below. *Abbreviations*: *IF* impact factor, *S* senior author, *Orig* original article, *CR* case report, *Rev* review, *Lett* letter

relatively small group of faculty, however, continued to produce research with good citation indices while a significant number could not do much research. This is reflected in the 44% of articles from FM/AUBMC with no citations, i.e. 2 SD below the mean of US medical schools in this parameter (Fig. 7, column 6). This was the lowest score for FM/AUBMC. Values for size-independent variables approach a normal distribution, with FM/AUBMC being: 1.4 SD below the mean for average citation per article, close to the University of Texas Medical Branch at Galveston; 1.2 SD below the mean in impact index, close to Medical University of South Carolina, Universities of Nebraska and Illinois; 1.3 SD above the mean in average number of publications per faculty, close to University of Texas Medical Branch at Galveston and 0.19 SD below the mean for average citations per faculty member, almost within the median. The values for the size-dependent parameters: total published articles, total citations, average number of faculty, and NIH funding do not follow a normal distribution curve, with means significantly higher than medians for these parameters and coefficients of variation above 1, reflecting tremendous variance for these size-dependent variables.

A study on research productivity at FM/AUBMC for the period 1996–2001 [23] revealed that in this 6-year period 18% of the faculty had no publications and only

Table 6 Total publications, total citations, adjusted IF of faculty members at FM/AUBMC members with H-index equal or above 15 in 2008

Faculty member	Total publications	Total citations	IF adjusted/year	H-index
1	67	7576	16.78	48
2	88	1724	12.39	24
3	36	2387	10.23	23
4	43	2025	18.92	23
5	47	1959	9.48	21
6	60	1294	20.11	19
7	29	929	8.33	18
8	41	758	3.69	18
9	43	1589	5.68	18
10	138	1741	9.13	17
11	25	1082	9.55	16
12	26	903	3.78	16
13	39	821	5.73	16
14	47	948	11.24	16
15	58	850	12.31	16
16	64	1011	12.24	16
17	31	743	2.67	15
Mean	**52**	**1667**	**10.13**	**20**
SD	**28**	**1606**	**5.11**	**8**
Correlation coefficient (total publications, H-index)		**0.18** Pearson's r: p is NS		
Correlation coefficient (total citations, H-index)		**0.98** $p < 0.0001$		
Correlation coefficient (total IF adjusted/year, H-index)		**0.47** $p < 0.001$		

Correlation coefficients r, are shown for correlating H-index with number of publications r = 0.18 (NS), with Citations r = 0.98 ($p < 0.0001$) and with "adjusted" IF r = 0.47 ($p < 0.001$)

20% had two or more publications per year. There was a significantly higher annual publication rate, expressed as publications per faculty per year (PFY), among newly recruited faculty; 1.67 ± 1.43 for those appointed after 1995; 1.45 ± 1.24 for those appointed during 1990–1995, and 0.93 ± 1.40 for those appointed before 1990 ($p < 0.007$), and higher among those who are younger in age ($p < 0.01$). Collaboration with international investigators resulted in a significantly higher number of original articles with higher "crude" IFs [23].

As to funding, Table 7 needs clarification. The mean NIH funding per faculty member in the USA in 8 years is $695,042 making the mean annual funding per faculty per year $86,880. This figure usually includes, in addition to bench/ground costs, overhead costs to the university, some equipment, salaries of technical assistance, and a pro-rata portion of the investigator's salary for the time spent on the project. The FM/AUBMC figure of $64,350 for 10 years, translating to $6435 per faculty per year is non-representative. The average number of faculty funded during this period was 48/192, making the mean awarded amount per funded faculty per

Table 7 Bibliometric indicators of FM/AUBMC shown as mean, alongside similar data that include means of the collected and synthesised bibliometric measures of 123 medical schools in the USA [24]. Total funding at AUB is not from NIH

	Published articles, 1997–2007	Citations to article published, 1997–2007	Average citations per article, 1997–2007	Impact index, 1997–2007	Percentage of articles with no citations, 1997–2007	Average number of faculty, 1997–2007	Total NIH funding, 1997–2005 (US dollars)	NIH funding per faculty member, 1997–2005 (US dollars)	Average number of publications per faculty member, 1997–2007	Average number of citations per faculty member, 1997–2007
Mean (μ)	9524	162,883	14.12	3.19	30.90%	823	$624,039,284	$695,042	10.27	157.08
Median	6779	88,708	13.67	3.16	30.20%	713	$355,369,774	$546,853	9.32	133.06
Standard deviation (σ)	10,828	244,785	4.55	0.63	6.30%	638	$665,327,229	$521,982	5.6	122.54
Coefficient of variation (C_v)	1.14	1.5	0.32	0.2	0.2	0.78	1.07	0.75	0.55	0.78
FM/AUBMC	3370	25,658	7.61	2.45	44%	192	12,355,226	64,350	17.55	133.64

year as $25,740, net of overhead, equipment, and investigator's salary portion. Overhead for external grants at AUB ranged from 0% to 20% e.g. the Lebanese National Research Council does not accept an overhead charge for its grants and European agencies hover around 10%, others go up to 20–22%, making the weighted average around 15% for external funding.

Determinants of internal funding included clarity of the proposal and its feasibility within the available facility, proposed budget, focus of the investigator and rate of productivity. All these were initially scored by peer evaluation, three referees per proposal. As experience developed, productivity was evaluated in addition, through a basket of bibliometric indicators.

The amount of funding depended on statistical analysis of costs of effective research at FM/AUBMC on a 5-year rolling basis, with the first period being 1995–2000. The cost of a wet -research-bench per month during that period ranged from $800 to $2000/month ($9600–$24,000/year), depending on the type of work; justified exceptions in a proposal were evaluated from available unit costs. The cost of a research assistant during that period was $6000–$8000 per year. Awards for wet research, therefore, range from $15,600 to $32,000 per year. Clinical research had a significantly higher variance in cost than basic wet research, depending on its nature, but the overall average during that period was slightly below the minimum of wet bench research.

3.5 Relevance and Outcome in Growth of Publications and Funding

Historically, internal funding was distributed "equitably" to all faculty members that submitted a proposal. A review of the process revealed that the money given is thinly spread and the amount to each investigator was inadequate for meaningful research. Groups of faculty members pooled their resources and worked jointly on a project. This was possible when there is a critical mass of investigators that can work on the same project.[7] A number of faculty members were left out to produce work without the needed support and hence a large number of publications had no citations. They were done to satisfy requirements for promotion, and 20% of faculty members had no publications between 1996 and 2001 [23]. The "equitable" became inadvertently "inequitable".

The funding policy was changed to define adequate support for each project (Sect. 3.4), the proposals were ranked and prioritized and the available money was given, without changing the proposals' approved budgets. Awards were given in descending priority until the money ran out. Some applicants did not get funding for that cycle. The adequate funding provided, research facility, research infrastructure, and the inclusion of bibliometric indicators in assessing research productivity, and

[7] The group in neurosciences at FM/AUBMC is an example, that also linked with investigators in the Faculty of Engineering.

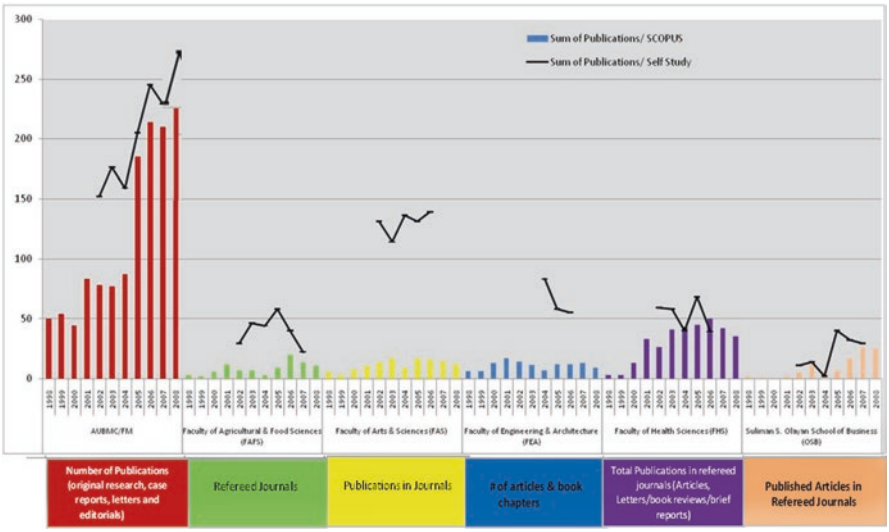


Fig. 3 Number of publications of AUB Faculties/Schools. The black lines above the bar graphs include publications extracted from all curriculum vitae of faculty members and input of recent publications to the Dean's office. The bar graph is extracted from Scopus for the years 1998 to 2008. The left-most panel is for the FM/AUBMC, followed by the Faculty of Agriculture and Food Sciences, Faculty of Arts and Sciences, Faculty of Engineering and Architecture, Faculty of Health Sciences (Public Health), and Suleiman Olayan School of Business. All publications represented in bars, are in peer reviewed and indexed journals as shown in the box below each faculty/school. This chart was prepared in 2008 by the provost for the AUB Self-Study, in preparation for reaccreditation by the Middles States Commission on Higher Education. (Source 1: Data from Working Group Five on Faculty responsible for writing "Faculty Chapter" in AUB Self-Study Report for AUB reaccreditation by Middle States Commission on Higher Education (2007–2008). Source 2: SCOPUS affiliation search by Faculty)

in promotion, resulted in a quantitative and qualitative shift in research productivity as shown in Fig. 3. The number of articles published each year, taken from the CVs, increased by 4.2-fold, from 67 articles in 1997 to 282 articles in 2008; and by 4.7-fold, from 50 articles to 236 articles indexed in Scopus. The bars represent data from Scopus and the solid black line above the bar graphs indicate the number of publications counted from the CVs. The number of articles per faculty per year increased by four-fold as per Scopus. The increase in the number of articles per Scopus was sustained beyond 2008, albeit by a 2.0-fold increase in publications, from 236 articles in 2008 to 463 articles in 2017 and a 1.5-fold increase in the number of articles per faculty member.

The number of publications started to increase as of 1997, with a jump in 2001 and another larger jump in 2005. The jump in 2001 is related to the establishment of the core research facilities that started to be operational as of 1997, but completely established in 1999 and to the newly introduced funding process; this gave the faculty on board the opportunity to increase their productivity, and succeed in attracting new younger active faculty to join FM/AUBMC as of 1995. The second jump in

Table 8 Intramural and extramural research funding for investigators at the FM/AUBMC from 1998 to 2008

	1998–2001	2001–2004	2004–2008	Total
Intramural	983,515	1,490,478	1,888,506	4,362,499
Extramural	703,220	2,110,202	5,179,305	7,992,727
Total funding	1,686,735	3,600,680	7,067,811	12,355,226

2005 was due to increased intramural research funding generated by the Medical Practice Plan (MPP), introduced in 2002, as shown in Table 8. The gap between the solid black line and bar values indicates that almost all published articles became indexed.

There are three major operational revenue sources at the FM/AUBMC: (i) student tuition for all teaching programs; (ii) patient-care revenue for all services at the medical center; and (iii) professional-fee revenue. In principal, students should not subsidize patient care and vice versa, similarly, academic physicians, as an association of independent contractors, should be paid for their teaching contributions and patient-care services but should not be subsidized further by students or from services of the medical center. They should be responsible for their costs, including benefits, cost of clinics/practice offices they use, and in addition, should contribute to investments for their individual and group professional-career growth. The latter expenses which included contribution to intramural research funds, trips to conferences, and paying recoupable support to newly recruited physicians, was set at a certain percentage of professional fee earnings and was made as a contribution to a Dean's Development fund (MDDF) for the purposes described. All net professional fee revenue otherwise goes back to the physicians with clear mechanisms for its sharing and distribution through group practices. The MPP defines, organizes, and legalizes the professional practice at the medical center. The increase in intramural research funding as of 2002 came from the MPP's Dean's fund (MDDF). The resulting increased research productivity increased the competitiveness of investigators at the FM/AUBMC, increasing extramural funding by about 5.5-fold between 1998 and 2008 (Table 8) and reversing the ratio of external to internal funding from 0.7 in 1998–2001 to 2.7 in 2004–2008.

4 Role and Impact of Bibliometrics in Recruitment and Promotion

Historically, the policy for recruitment and promotion at FM/AUBMC required a specific number of publications for each rank, usually accomplished within a specified period of time. Evaluation of research was through peer review, which is characterized by expert opinion evaluating content, thought process, focus, relevance, worth in discipline, fundability, and potential sustainability. The review process contributes to peer learning and research improvement. The limitations of peer

review include subjectivity, possible bias, inconsistency, being time consuming with variable response rate, and is relatively costly. The peer-review process is very well developed in the USA, with growing experience, evolving through the peer-review process for NIH funding, expanding rapidly in time to a multibillion US dollar budget. The outcome from NIH research contributed to important ground-breaking discoveries and patents; 153 Nobel Prize laureates received NIH funding.[8] The success of this process made NIH funding a major determinant of research productivity [12] and to a large degree, of recruitment, promotion, and tenure appointments in medical schools in the USA. Although there is similarity between the research enterprise in the USA and west Europe, this is not the case for west Europe where paid skilled peers are selected to evaluate proposals, the system does not have the collective historic experience and there is more need to depend on measurable key indicators. That is why measurable key indicators, primarily the journal IF, became a significant determinant of research evaluation in Europe [12]. At FM/AUBMC, the University invites a specified number of peer referees, usually from the USA and sometimes from Europe and/or elsewhere, to review and evaluate the candidate's research productivity. This provides an international dimension. Referees are selected by the President of the University, Dean of the Faculty, Chair of the Department, and candidate for promotion. There is no critical mass of qualified peers in all disciplines in Lebanon and the region and the few that exist would be overwhelmed by the process. Unless the candidate for promotion has been recruited from the US and has passed there through the process for recruitment, promotion and/or have been awarded NIH funding in the USA, the "peers" find it difficult to evaluate productivity in Lebanon. Variants of the following statement is often seen in their letters, "I do not know (the candidate), s/he seems to have the number of publications required for promotion at your institution. I cannot compare him with candidates for promotion at our institution. Senior colleagues at your institution are best fit to evaluate her/his work". This was particularly true with candidates that had the required number of publications but no citations. Introduction of measurable indicators, as in Europe, to supplement the peer-review process, became imperative. Bibliometric evaluation is objective, verifiable, reproducible, discipline specific, and may be benchmarked. Limitations include the requirement for trained evaluators, is subject to false interpretations by non-experts, and does not directly address content, thought process, focus, relevance, and worth in discipline. The bibliometric indicators used are shown in the faculty profile (Fig. 2 and in Table 7) for benchmarking with USA medical schools. The journal "crude" IF was adjusted, as presented in Sect. 2.2, for the author's specific types of publications and position as an author. The "adjusted" IF was informally determined in 1998 for 40 faculty members recently promoted to associate professors with tenure, in different departments/disciplines of eight medical schools in the USA, three of which are in top-ranking universities. The "adjusted" IF was less than 8 in 5/40 recently tenured faculty members and less than 6 in 1 faculty member. An FM target of 8 "adjusted" IF was set for statistical purposes, to determine the approximate number of faculty

[8] NIH website.

members that have a research productivity that matches those that may qualify for tenure in the USA, or long-term 7-year contracts at AUB. Passing this threshold, adjusted to the discipline, only helped in initiating the process of applying for long-term contracts at AUBFM but its success depended on fulfilling all criteria for such a promotion.

In addition to the research profile, the education profile, and for practicing faculty, the clinical workload profile as well as lists of patents, invited lectures, and funding became part of the package sent to the referees. The available information gave the referee all the essential basic information at a glance and allowed them to focus on content, thought process, relevance in the field, and future potential. Many referees compared the candidate to those in their institution and, for some candidates, stated that they would qualify for tenure there. Response rates improved significantly and referees made comments on the adequacy of the package, such as "Thank you for asking me to comment on the promotion of (name). I appreciate receiving such a comprehensive package and especially being provided with the quantitative and analytic materials on (name) I do not know (name) personally but, I am impressed by the provided materials …"[9]; and also "The packet sent is the most complete candidate information I have received in over 20 years. The university is to be congratulated for its inclusiveness…."[10]

4.1 Lessons Learnt from Bibliometrics in the Promotion Cycle

The candidate either initiates the process of promotion or is reminded that it is time to apply. The application is submitted to include all profiles discussed in Sect. 4. Letters to peer referees are sent. All applications are discussed by meetings of members of the department in the rank to which candidates are applying and higher. The candidates are compared to peers in the rank. The chair adds his recommendations in a letter with the minutes of the meeting. The dean discusses applicants from all departments with the Dean's Advisory Committee, consisting of senior professors elected by the faculty assembly and includes representations of basic science, medical, surgical, and service departments. The dean submits his letter, with the entire package including minutes of all meetings, the chair's letter and responses of the peer referees to the Board of Deans (BOD) where candidates are compared with those from all other Faculties of the University. Each dean defends his recommendations. The BOD makes recommendations on each candidate to the President, who submits the packages with the BOD's and his input to the Board of Trustees, the guardian of standards of the University, for final decision. The process is illustrated in Fig. 4.

[9] Judith S. Palfrey, MD, The T. Berry Brazelton Professor of Pediatrics, Harvard Medical School. Chief, Division of General Pediatrics, Children's Hospital Boston, letter to Dean Nadim Cortas dated December 18, 2007.

[10] Richard A. Kozarek, M.D. Professor of Medicine, Director of Digestive Disease Institute, Chair of GI research, Virginia Mason Medical Center. Letter dated October 27, 2006.

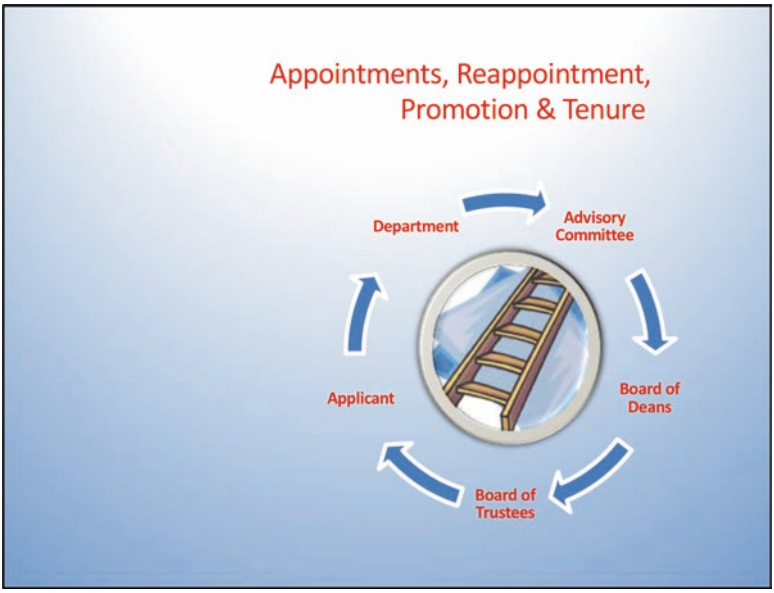


Fig. 4 Appointment, reappointment, promotion, and 7-year, (tenure since 2017) cycle at the Faculty of Medicine, AUB. The Dean's Advisory Committee is elected by the faculty at large from full professors representing the basic science, surgical, medical (non-surgical) and clinical service departments, all other bodies are ex-officio

Data from the research profile of each applicant are pooled and analysed for the mean and standard deviation for each indicator in a defined group. The data for the "adjusted" IF are presented for all applicants for promotion to associate professor and to professor, pooled together and independently. Most research universities in the USA link promotion to associate professor to tenure. The rank otherwise becomes modified. The applicants to both ranks are reported and pooled to see on one graph, the candidates above the informally set threshold for long-term contract or tenure. The data for 1998–2008 are shown in Fig. 5 for candidates for promotion and Fig. 6 for promoted candidates. The diamonds represent candidates with "adjusted" IF of 6 or above, 15 candidates were above 8 and 10 were from 6 to 8. The trend line, obtained by linear regression, for all applicants had a positive slope. The troughs and peaks were due to the particular mix of candidate disciplines in each year. Examining Fig. 6, the trend line is 1.38-fold steeper than that of Fig. 5. If the trend continues, the trendline will hit the threshold mark not long after 2010, allowing for troughs and peaks. This will make a significant proportion of those promoted in the unmodified university track above the threshold, with the ultimate target to have almost all those promoted to associate professor in the future, potentially eligible for becoming tenure. Many other criteria, in addition, must be satisfied for such a promotion. It is interesting to note that AUB re-established tenure appointment in 2017 and all applicants for the first cycle were evaluated by tenured professors chosen by the university from a tenured pool of professors in the

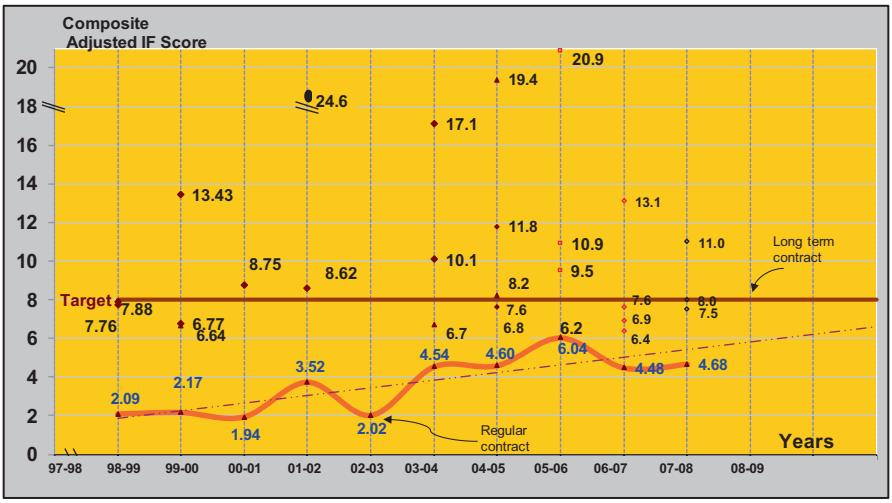


Fig. 5 Research productivity of all *applicants* for promotion in the Faculty of Medicine by year. The "adjusted" impact factor on the vertical y-axis is shown as a function of time in years on the horizontal x-axis. The solid wavy line connects the mean "adjusted" impact factor for all applicants for each year. The solid line, parallel to the horizontal axis represents the chosen "target" threshold "adjusted" IF of 8, above which candidates are to be considered, for long term or tenure appointments. Candidates with "adjusted" "impact factor of 6 or above are indicated by "diamond" points. The "dotted" line shows the trend line, obtained by linear regression, of mean adjusted IF over time

USA. Twenty-six applied from the FM and 20 were awarded tenure, 16 of those would have been predicted from this model and are included in the "diamonds" in Fig. 6 or, for appointees recruited as professors during that period, with high H indices in addition, shown in Table 6. There were three borderline cases, two made it and one did not. The other four had tenure appointments in the USA and were recruited later to senior positions at FM/AUBMC.

A new FM policy was introduced in 2002 for appointment, re-appointment, and promotion. It defines the requirements for promotion in three tracks, an unmodified university track, e.g. assistant, associate or professor; a modified suffixed track e.g. assistant, associate or professor of clinical (specialty name inserted e.g. internal medicine, surgery), and a prefixed rank e.g. clinical assistant, associate, or professor of (specialty name inserted). Appointees in all tracks contribute variably to the teaching programs in the FM. Appointees in the unmodified track can be made by all departments in the FM and holders are expected to contribute a significant effort in research and ultimately, acquire external funding, although some may do that through their practice. The requirements for promotion in this track are the same as for all other Faculties of the University.[11] Appointees in the modified tracks are for faculty with significant clinical practice and are appointed by any of the clinical departments at the

[11] The unmodified university track was renamed in the policy approved in 2012, the investigators track with scientist investigator and physician investigator sub-tracks.

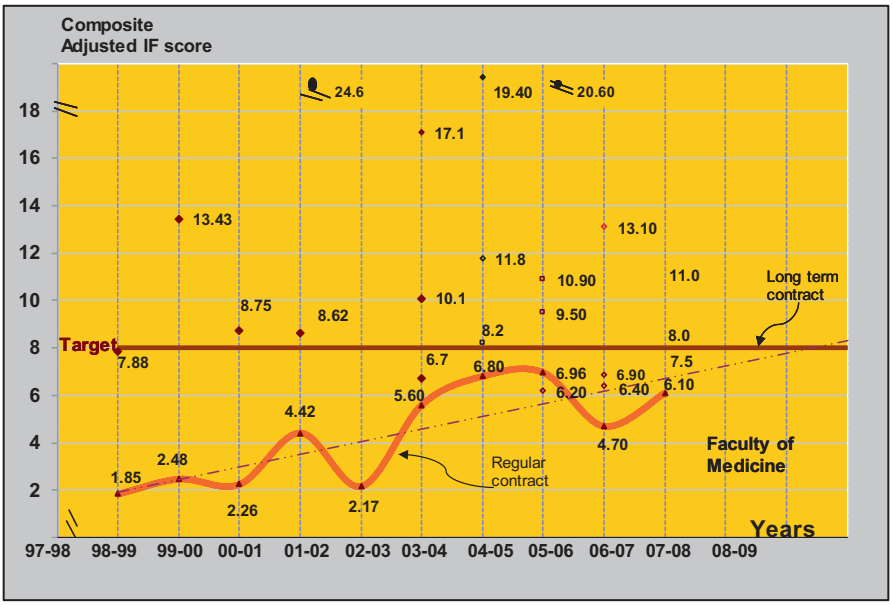


Fig. 6 Research productivity of all *promoted applicants* in the Faculty of Medicine by year. The "adjusted" impact factor on the vertical y-axis is shown as a function of time in years on the horizontal axis. The solid wavy line connects the mean "adjusted" impact factor for all applicants for each year. The solid line, parallel to the horizontal axis represents the chosen "target" threshold "adjusted" IF of 8, above which candidates are to be considered, for long term or tenure appointments. Candidates with "adjusted" impact factor of 6 or above are indicated by "diamond" points. The "dotted" line shows the trend line, obtained by linear regression, of mean adjusted IF over time

FM. Appointees in the suffixed track[12] will spend 600 h per year at the discretion of the department chairperson in basic and clinical teaching, in research and in administration, while appointees in the prefixed track[13] will spend 300 h at the discretion of the chairperson for the purpose and more time in clinical practice. The discretionary time was modified in the 2012 revision of the policy and expressed as % of effort. The expected scholarly output in each category is defined in an appendix to the policy of 2002. Full-time appointees in the three tracks who are involved in patient care participate in the MPP. The new definition of the prefix track in 2002, allowed a number of part-timers from the 1970s to 1990s to transition to full time. Among the goals of this policy is to define further essential groupings within the faculty and build adequate critical masses in each. The standards expected for promotion in the three tracks did not differ significantly and hence appointees in the modified tracks were given 1 year and 4 years more respectively to achieve the requirements for promotion to the associate professor and professor ranks in their track. For this reason and because the number of applications from each group is small, candidates applying to the same rank from the three tracks were pooled. This contributed to the "wavy" lines in Figs. 5

[12] Suffixed clinical track was renamed in the 2012 policy as the Physician-educator track.

[13] Prefixed clinical track was renamed in the 2012 policy as the Academic Clinician track.

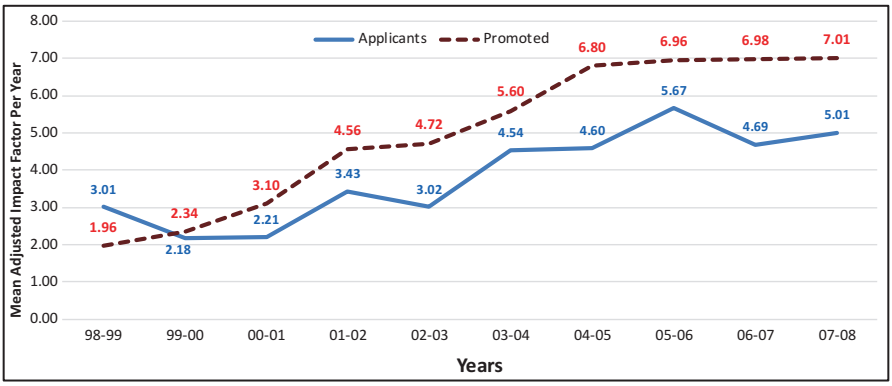


Fig. 7 Research productivity of all *candidates in the Basic Science Departments*. The mean "adjusted" IF per year on the vertical axis is shown as a function of time in years on the horizontal axis. The dashed line connects the mean "adjusted" IF for all *promoted* candidates for each year. The solid dark line connects the mean "adjusted" IF for *all candidates* for each year

and 6. The data collected from the pooled basic science departments with appointments in one track, shown in Fig. 7 demonstrate significantly less "wavy" curve lines, especially for promoted candidates. This group had a head start because of earlier adequate funding and the availability of the core facility as of 1997.

"Adjusted" IF data were analyzed for associate professors and professors independently and as shown in Fig. 8, for all applicants, and Fig. 9, for promoted applicants; the "peaks" and "troughs" were much larger for professors than associate professors. This is not surprising since assistant professors ready for promotion to the rank of associate professor as of 2002 onward were appointed, as of 1995, with the idea to rejuvenate the faculty and were selected with equivalent criteria and standards, in contrast to those recruited during the war period, some were excellent and some were recruited because of need. The former, more homogenous group had higher publications rates than their predecessors as summarized in Sect. 3.4 [23]. The candidates to the rank of professor were from a more heterogeneous group that included fresh recruits and other candidates who have been in rank for 11 years and prior to that, heavily involved in practice and teaching during the war years. Both Figures clearly exhibit the positive trend line in gradually increasing candidate's mean "adjusted" IFs over time (Fig. 9).

4.2 Impact of Gradually Increasing the Bar for "Adjusted" IF on Promotion Rate

The trend line for "adjusted" IF increased with time, but as shown in Table 9, without altering the rate of success, with the rates of promotion for associate professors, professors, and overall success, fluctuating randomly around means of 73–77%, indicating that there was an increase in overall research productivity rather than weeding out a larger number of candidates with lower productivity.

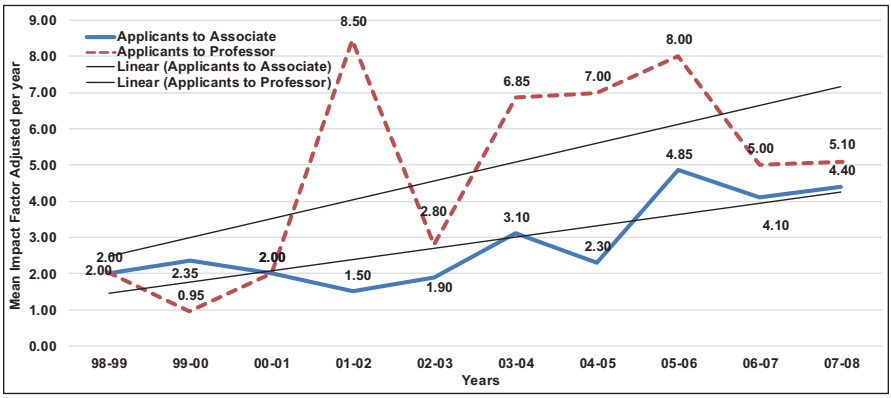


Fig. 8 Mean "adjusted" IF Per Year for *applicants* for promotion. The mean "adjusted" IF per year on the vertical axis is shown as a function of time in years on the horizontal axis. The dashed line connects the mean adjusted impact factor *for all applicants* to the rank of Professor for each year. The solid dark line connects the mean "adjusted" IF for *all applicants* for promotion to the rank of Associate Professors for each year. The trendlines, obtained by linear regression, are drawn for each category

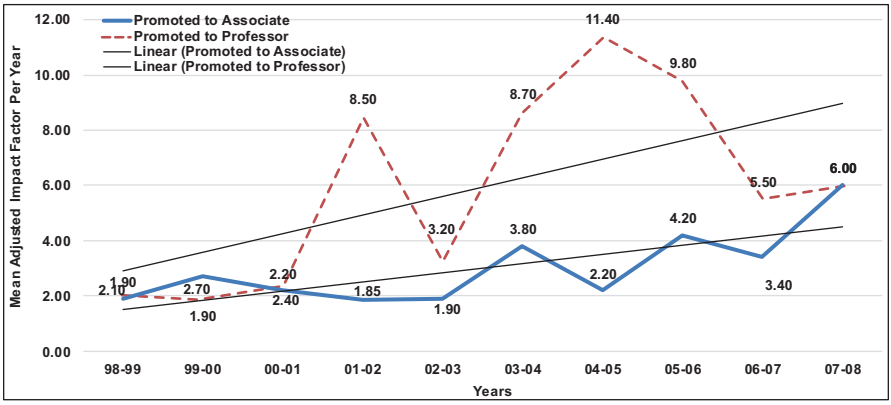


Fig. 9 Mean 'adjusted' IF Per Year for *promoted* candidates. The mean "adjusted" IF per year on the vertical axis is shown as a function of time in years on the horizontal axis. The dashed line connects the mean "adjusted" IF for all promoted candidates to the rank of Professor for each year. The solid dark line connects the mean "adjusted" IF for all *promoted* candidates to the rank of Associate Professors for each year. The trendlines, obtained by linear regression, are drawn for each category

5 Faculty Effort Analysis

Faculty effort analysis was performed as described in Sect. 2.6; the results for 2007–2008 are summarized in Tables 10 and 11.

The data for each department shown in Table 10 reveal that for the basic sciences, the greatest variance is found in the proportion of time spent per faculty member in

Table 9 **Promotion** *success rate*. In each year from 1998 to 2008, the figures on the left in each column indicate the total number of promoted or declined in both of the two ranks. The numbers on the right indicates those promoted or declined to either Associate Professor or Professor

Promotion success rate	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	Overall
Total applicants	**15**	**23**	**20**	**15**	**13**	**10**	**15**	**10**	**14**	**14**	**4**	
Promoted	**8**	**16**	**17**	**11**	**10**	**8**	**8**	**8**	**13**	**9**	**4**	
To rank of Asso Prof	7	15	11	6	4	5	4	5	2	3	3	
To rank of Prof	1	1	6	5	6	3	4	3	9	6	1	
Declined	**7**	**7**	**3**	**4**	**3**	**2**	**7**	**2**	**1**	**5**	**0**	
To rank of Asso Prof	7	5	0	0	1	1	4	1	1	2	0	
To rank of Prof	0	2	3	4	2	1	3	1	0	3	0	
Success rate to Associate Professor	**50%**	**75%**	**100%**	**100%**	**80%**	**83%**	**50%**	**83%**	**67%**	**60%**	**100%**	**77%**
Success rate to Professor	**100%**	**33%**	**67%**	**56%**	**75%**	**75%**	**57%**	**75%**	**100%**	**67%**	**100%**	**73%**
Overall success rate	**53%**	**70%**	**85%**	**73%**	**77%**	**80%**	**53%**	**80%**	**93%**	**64%**	**100%**	**75%**

Table 10 Mean percent effort of faculty members of each academic department in teaching, research, academic, and clinical administration, clinical service, and clinical training for 2007–2008

Academic Departments	2007–2008					
	Teaching	Research	Academic administration	Clinical administration	Clinical service	Clinical training
Biochemistry	37%	46%	16%	0%	0%	0%
Human Morphology	46%	43%	9%	0%	1%	1%
Microbiology & Immunology	28%	55%	17%	0%	0%	0%
Pharmacology	31%	40%	27%	2%	0%	0%
Physiology	30%	62%	8%	0%	0%	0%
Basic Departments	**34%**	**49%**	**17%**	**0%**	**0%**	**0%**
Anesthesiology	15%	6%	2%	6%	56%	17%
Dermatology	6%	5%	3%	1%	62%	24%
Diagnostic radiology	9%	8%	1%	3%	38%	41%
Emergency medicine	8%	5%	5%	16%	48%	18%
Family Medicine	8%	5%	4%	4%	70%	9%
Internal Medicine	16%	10%	6%	6%	44%	18%
Obstetrics & Gynecology	14%	10%	4%	2%	53%	17%
Ophthalmology	16%	5%	2%	3%	56%	18%
Otolaryngology	11%	13%	6%	3%	41%	26%
Pathology & Lab. Med	22%	13%	5%	11%	40%	9%
Pediatrics	15%	10%	6%	3%	41%	25%
Psychiatry	NA					
Surgery	6%	5%	3%	5%	57%	26%
Clinical Departments	**12%**	**8%**	**5%**	**5%**	**50%**	**20%**

academic administration, this includes administrative functions of the chairperson and time of faculty spent in the various academic committees of the department, Faculty, and the University. The higher percentages occurred in the smaller departments, no other reason was found for this variance. Total number of faculty members in the basic science departments at the FM ranged between 17 and 20 Full-Time Equivalents (FTEs),[14] with a mean of five per basic science department and a range of 3–8, these numbers are much smaller than counterparts in the USA. Normalizing

[14] Full Time Equivalent (FTE) is full-time effort given for a defined function e.g. if three faculty members give 40%, 25% and 35% effort respectively for a function e.g. research, the three will constitute one FTE of research.

Table 11 Upper 3 rows show the total number of hours spent in teaching, research, academic administration, clinical administration, and clinical teaching/training, as reported by faculty members in basic science departments, clinical departments and total of both. The lower 3 rows show the % time spent in each

Department type	Teaching	Research	Academic administration	Clinical administration	Clinical service	Clinical training	Total hours
Basic Departments	12,865	18,756	6314	135	96	62	38,228
Clinical Departments	53,232	40,645	22,541	25,134	253,519	99,583	494,654
Total	66,097	59,401	28,855	25,269	253,615	99,645	532,882
Basic Departments	34%	49%	17%	0%	0%	0%	100%
Clinical Departments	11%	8%	5%	5%	51%	20%	100%
Weighted Average	12%	11%	5%	5%	48%	19%	100%

the weighted administrative effort of 17% to the benchmarked norm of approximately 5–7% yields the need for at least 49 (or 50) faculty full-time equivalents (FTEs) i.e. 10 FTEs/department for optimal administrative efficiency. This means that the current total administrative effort spent by basic science departments, which is 3.5 FTEs (17% of 20 FTEs) is adequate, by the norm of 7%, for 50 FTEs. Improving efficiency by hiring more basic scientists is not feasible for lack of need, resources, and space. Amalgamating the basic science departments to one academic unit, as an alternative, will require the same administrative effort of one department and, therefore, will relieve the current administrative effort by two FTEs that will become available for teaching and research. This provides an example of how metric analysis is important to right size and then grow by plan. In fact, an Academic Review Team,[15] invited by AUB's President John Waterbury in 1999, chaired by Paul Griner and included Nobel Prize laureate Torsten Wiesel, recommended in their report, amalgamating the basic science departments at the FM to one or two academic units for the purpose of creating more efficient critical masses.

Faculty Effort is reported in the upper 3 rows of Table 11, in hours spent by members of clinical departments, basic science departments, and the weighted average of both. The behavior of the larger clinical departments is within the spectrum of the benchmarked norm. The total number of reported hours spent in curricular teaching and in clinical training is 165,742 h, the mean number of hours per FTE per year at work was 1800 h (1680–2400), which translates to 92 FTEs per year. Teaching of the undergraduate medical curriculum, both basic and clinical, including

[15]The Academic Review Team included. Paul Griner, M.D., Chair, J. Robert Buchanan, M.D. Ramsey Cotran, M.D. Linda Lewis, M.D. George Thibault, M.D. Torsten Wiesel, M.D. Their Report submitted to AUB in 1999 also describes the Research Core Facilities at the FM as "state of the Art."

a relatively small MS program with a number of courses overlapping with medicine, requires 60 FTEs. This number agrees with the FTE requirement calculated independently from the number of credits taught, class sections, and teaching hours currently given. The remaining 32 FTEs cover all residency and fellowship programs. Residency and fellowship training is symbiotic for the mentor and trainee, both benefitting, and hence, there is no mentor compensation.

The same analysis for clinical administration reveals that the reported total number of hours per year spent on clinical administration by chairpersons, heads of divisions, and all other faculty members on clinical departmental, medical board, hospital, and ad-hoc committees is 25,269 h, which translates into 15 FTEs. This is in addition to the clinical administration efforts of those who did not participate in the faculty-effort-analysis process since their roles are purely administrative and include: the Dean/VP (0.6 FTE), Chief Medical Officer (1 FTE), Chief of Staff (1 FTE), administrative positions in the Department of Anesthesiology (0.84 FTE), Laboratory Medicine (0.78 FTE), and Diagnostic Radiology (0.47 FTE), making the total 19.65. This is in agreement with the projections of 21 FTEs for a 425-bed hospital made by the Joint Commission Worldwide Consultants in their report for AUBMC.[16] Similarly, research effort is equivalent to 33 FTEs, 11 of which in basic sciences. The reported effort of FTEs in patient care (clinical service) is 140 FTEs.

All this information is presented to illustrate the importance of starting with strategic faculty recruitment to effect sustainable growth and engage in mission-based growth and budgeting. As per FM/AUBMC mission, the medical undergraduate education enterprise is not likely to grow much and the 60 FTEs, allocated to the FM budget are expected to increase marginally, so are the 21 clinical administrative FTEs at the AUBMC. On the other hand, the net 140 FTEs for patient care may increase significantly by two to threefold as per the mission and vision for clinical service and training. Each mission will therefore grow at its pace without encumbering the others. Mission-Based budgets with 5–10 year plans for education, research, hospital services and professional care were built independently. Education FTEs are allocated to the FM budget, clinical training and service FTEs to the hospital budget, patient care professional FTEs to the Medical Practice Plan (MPP) budget, and research, internally to the stakeholders, through the University Research Fund (URB), Dean's research fund, and the Dean's MPP Fund while the hospital, through the Chief of Staff office, paid for research aimed at performance improvement. External funding is competitive and grew substantially (Table 8). The mean $ 472,120 internal funding available/year (2004–2008) increased from $328,000 in 1998–2001, supports significantly on average 16 bench/ground projects and the mean $ 1,294,826/year of solicited external funding, increased from $234,406 in (1998–2001) supports 44 bench/ground projects.

Faculty members were recruited primarily from the USA from 1997 to 2009 and hence remuneration was based on the published AAMC tables for salaries in the

[16] The Joint Commission Worldwide and Health Care Consultants, USA, were invited by President John Waterbury in 1998 to review the AUBMC, and concluded their work by an extensive report entitled "AUBMC, Strategic and Operational Assessment".

USA, adjusted to differences of taxes in the US and Lebanon. The departmental percentile standing was determined and take-home pay was established from published ratios between ranks. The floor income consisted of allocations to education, research, academic administration (FM budget), and clinical administration (AUBMC budget). Professional patient care income was distributed as per MPP. The process resulted in planned recruitment of 110 faculty members, on average, 10–12 faculty members per year, driven by the growth of the MPP and for whom the facility and infrastructure is prepared. The critical mass for PhD mentors was achieved, setting the stage for unfreezing the program few years down the line.

The quality of the process from 2000 to 2009 resulted in the following recognitions: Accreditation of the programs of the FM and the School of Nursing (SoN) by the Middle States Association of Colleges & Schools (USA), and also for the SoN, accreditation by the Committee on Collegiate Nursing Education (CCNE) of the American Association of Colleges of Nursing. For AUBMC, accreditation by the Joint Commission International (JCI), by the College of American Pathologists (CAP), and for the nursing service, the prestigious Magnet designation.

6 Conclusion

This chapter relates the journey of re-establishing post war, an institutional research enterprise at the FM/AUBMC of the American University of Beirut. The plethora of universities that emerged in the Arab world as of the 1990s may have similar challenges as that of post-war AUB. A clear vision and mission for education, research, and patient care guided the process. The environment for research and research funding is different in developing countries compared with developed countries such as the USA and west Europe. A formal peer-evaluation process needs to be established. Bibliometric indicators were introduced starting with the investigator's citation index as of 1955 and the methodology was applied later to journals, as in the journal IF. Citation analysis (14–19) identified groupings, each with its peculiarities that work within various disciplines. Application of the journal IF to institutions was limited by size dependency. Mathematical manipulation to attenuate this variable resulted in the introduction of the Impact Index [25]. To include the impact of both, the number of publications and citations together, the H-index was introduced [21]; it proved significantly predictive for research assessment and success of individual investigators. A number of H-index variants were introduced [22] to attenuate limitations for specified circumstances. The Journal IF, and later the H-index, rapidly gained popularity and importance, particularly in Europe. It became an essential tool to assess, stimulate research productivity and at the same time, guide decisions in allocating research funds, improve performance, and perform benchmarking with similar institutions locally and across the globe. The "adjusted" IF, introduced at FM/AUBMC in 1999, takes into consideration the type of article (s) published and position of author (see Sect. 2.2) and correlates well with the H-index (Table 6).

A database from which the faculty research profile (Fig. 2) is automatically generated was developed that includes: the number of papers, percent of articles not cited, the total number of citations for each investigator, the average citations per paper, percentile ranking of each journal within its discipline, impact factor ("crude" IF), "adjusted IF, impact index, and H-index. These were also expressed per year and per article. The research, teaching, and clinical workload profiles can be seen at a glance. The evaluator can hence concentrate on content, thought process, focus, relevance, and feasibility of the investigator's work. This markedly enhanced external peer-review evaluations. Targets of performance including bibliometric indicators incentivized investigators, particularly when resources are made available.

The availability of adequate funding, research facilities, research infrastructure, and the inclusion of bibliometric indicators in assessing research productivity, and in promotion, resulted in a quantitative and qualitative shift in research productivity as shown in Fig. 3. The number of articles published from 1998 to 2008, as per Scopus, increased by 4.7-fold. The number of articles per faculty per year increased by fourfold. This was sustained beyond 2008, albeit by a 2.0-fold increase in publications and a 1.5-fold increase in the number of articles per faculty member by 2017. The quality of publications, gaged by a basket of bibliometric indicators also improved, particularly among those recruited after 1995. This enhanced the competitiveness of investigators at the FM/AUBMC, increasing extramural funding by about 5.5-fold between 1998 and 2008 (Table 8) and reversing the ratio of external to internal funding from 0.7 in 1998–2001 to 2.7 in 2004–2008. Available funding for conference travel encouraged investigators to present at international meetings and become recognized within the networks of their discipline. This gave more visibility to AUB.

The realistic and transparent targets for research, established for appointment and promotion improved the quantity and quality of research at the time of promotion without decreasing the success rate. The number of faculty members that would qualify and are likely to get long-term contracts (tenure after 2017 at AUB) or tenure appointments in peer institutions increased.

In benchmarking with similar data for 123 medical schools that are members of the American Association of Medical colleges (AAMC), obtained from 1997 to 2007 [24], the FM/AUBMC fits within the distributions of all the size-independent parameters reported for the USA schools.

Effort analysis provided data that markedly enhanced the process of Mission Based Budgeting and Management. A strategic faculty recruitment plan was critical for success at FM/AUBMC. Chung et al. [26] reports the same for a surgery department.

Applying a basket of bibliometric measures provides an overview of research at the FM, departments and by individual investigators. This data are now easy to obtain from web based databases, with literature comparing these databases [27, 28].

Bibliometric analysis strongly complements but does not replace current peer-review methodology in research assessment. It significantly improves decision-making for research funding, space distribution, and planning. It facilitates benchmarking internally and externally and strongly catalyzes development of a peer-review process in developing countries.

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