

July 26, 2021

James D. Fielder, PhD
Secretary
Maryland Higher Education Commission
6 North Liberty Street
Baltimore, MD 21201

Dear Secretary Fielder:

The University of Maryland, Baltimore is seeking authorization to offer a Master of Science (MS) in Clinical Informatics. Our proposed program leverages institutional expertise from both UMB and UMBC to tackle systemic problems in Clinical Informatics. In order to enhance health outcomes, improve patient care, and strengthen the clinician-patient relationship, this program will apply biomedical data, computational systems and clinical process improvement to the practice of medicine.

The program will be offered as a mixture of didactic coursework and practical training, with 34 credits required for a MS. All didactic courses will be accessible online. The practical courses will have both on-site and online options. The proposed degree will allow students with a professional healthcare background to be trained in best practices of Clinical Informatics. The program will be geared toward physicians, nurses, pharmacists, other healthcare professionals, biologists, and other scientists, who will study and apply informatics approaches to enhance their professional skills. The program will focus on biomedical data, computational systems, and clinical process improvement, which students will apply to the practice of medicine and to clinical decision support, in order to enhance health outcomes, improve patient care, and strengthen the clinician-patient relationship. We plan to offer this program beginning with the Fall 2022 term.

Thank you for your time and consideration of this request. Please contact me if you need additional information.

Regards,



Dr. Roger J. Ward, JD, MSL, MPA
Interim Provost and Executive Vice President
Dean, Graduate School



Cover Sheet for In-State Institutions

New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	University of Maryland, Baltimore
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Each action below requires a separate proposal and cover sheet.

- | | |
|---|---|
| ☒ New Academic Program | ☐ Substantial Change to a Degree Program |
| ☐ New Area of Concentration | ☐ Substantial Change to an Area of Concentration |
| ☐ New Degree Level Approval | ☐ Substantial Change to a Certificate Program |
| ☐ New Stand-Alone Certificate | ☐ Cooperative Degree Program |
| ☐ Off Campus Program | ☐ Offer Program at Regional Higher Education Center |

Payment ☒ Yes	Payment ☐ R*STARS #	Payment Amount: \$850	Date Submitted: 7/15/21
Submitted: ☐ No	Type: ☐ Check #		
Department Proposing Program	University of Maryland Graduate School		
Degree Level and Degree Type	Master's Degree		
Title of Proposed Program	Clinical Informatics		
Total Number of Credits	34		
Suggested Codes	HEGIS:	CIP: 51.2706	
Program Modality	☒ On-campus ☐ Distance Education (<i>fully online</i>)		
Program Resources	☒ Using Existing Resources ☐ Requiring New Resources		
Projected Implementation Date	☒ Fall ☐ Spring ☐ Summer Year: 2022		
Provide Link to Most Recent Academic Catalog	URL: https://iq3prod1.smartcatalogiq.com/Catalogs/University-of-Maryland-Baltimore-Graduate-School/2020-2021/Graduate-Catalog		
Preferred Contact for this Proposal	Name: Dr. Courtney Resnick		
	Title: Director, Academic Administration		
	Phone: (410) 706-1527		
	Email: cresnick@umaryland.edu		
President/Chief Executive	Type Name: Dr. Roger Ward, Interim Provost and Executive V.P.		
	Signature:		Date: 07/22/2021
	Date of Approval/Endorsement by Governing Board:		

Revised 1/2021

**A PROPOSAL FOR A NEW ACADEMIC PROGRAM at THE UNIVERSITY OF
MARYLAND, BALTIMORE FOR A MASTER OF SCIENCE IN CLINICAL
INFORMATICS**

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A. Centrality to Institutional Mission and Planning Priorities:

1. Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission.

The University of Maryland, Baltimore (UMB) submits this proposal to create a Master of Science in Clinical Informatics. We intend to offer it as a mixture of didactic coursework and practical training, with 34 credits required for a Master of Science (MS). All didactic courses will be accessible online. The practical courses will have both on-site and online options. The proposed degree will allow students with a professional healthcare background to be trained in best practices of Clinical Informatics. The program will be geared toward physicians, nurses, pharmacists, other healthcare professionals, biologists, and scientists, who will study and apply informatics approaches to enhance their professional skills. The program will focus on biomedical data, computational systems, and clinical process improvement, which students will apply to the practice of medicine, in order to enhance health outcomes, improve patient care, and strengthen the clinician-patient relationship.

The Master of Science in Clinical Informatics will be organized around two PBCs of Professional Studies in Data Science (currently offered by UMBC) and in Clinical Informatics (proposal forthcoming from UMB), along with hands-on practicums and conferences. The PBC of Professional Studies in Data Science will be hosted by UMBC, and the other courses will be hosted by UMB to form a joint institutional collaboration. Full-time and part-time plans of study will be available to students. The curriculum will be a joint effort, using clinical and practical courses taught at UMB along with data science courses from UMBC. The hands-on practicums will be supervised by UMB and UMBC faculty with advanced training in Clinical Informatics and Computer Science, and focus on relevant clinical projects at the University of Maryland Medical Center and the University of Maryland School of Medicine.

The program will prepare students from a wide range of healthcare backgrounds for careers in clinical data science and clinical informatics. They will provide leadership and expertise in the procurement, customization, development, implementation, management, evaluation, and continuous improvement of clinical information systems. They will work with a large range of computational systems, including electronic health record systems, decision-support systems, practice management tools, imaging systems, clinical research systems, and public health systems. They will find employment as Chief Medical Information Officers (CMIOs), researchers, educators, and in industry, all of which are in high demand. In addition, by obtaining ACGME certification, qualified physicians who complete the program can become board-eligible in the ABMS specialty of Clinical Informatics. For other health professionals and scientists, completion of this program, along with other professional activities, can lead to eligibility as a Fellow of the American Medical Informatics Association.

2. Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority.

UMB has a long history of developing qualified healthcare professionals. The program in Clinical Informatics continues this tradition by recognizing the need for interdisciplinary professionals with training in both informatics and healthcare. The new medical subspecialty in Clinical Informatics is further evidence of the need for multidisciplinary individuals to lead the data revolution in healthcare. The knowledge and skills in Clinical Informatics are crucial to future success in patient care, biomedical research, and public health, as well as to health policy design and implementation. The American Medical Informatics Association (www.amia.org) estimates that 70,000 trained specialists are needed in the near future to support these efforts, with other estimates in 2018 as high as 150,000 specialists, if all hospitals followed the Electronic Medical Record Adoption Model (JAMIA Open. 2018 Oct; 1(2): 188–194).

The M.S. in Clinical Informatics program directly aligns with the first theme of UMB's strategic plan, "Health, Justice, and Social Impact", in order to "deepen and expand local and global engagement by providing health, legal, and social work programs and engaging in research to promote social justice and improve health." Our proposed program leverages institutional expertise to tackle systemic problems in Clinical Informatics. In order to enhance health outcomes, improve patient care, and strengthen the clinician-patient relationship, this program will apply biomedical data, computational systems and clinical process improvement to the practice of medicine. The proposed program also supports UMB's second theme, "Research and Scholarship", by harnessing our interdisciplinary strengths across UMB and UMBC in Clinical Medicine and Computer Science, respectively. Related to this, the proposed program also supports UMBC's strategic goal, "Collective Impact in Research, Scholarship, and Creative Achievement", by increasing national prominence in selected multidiscipline areas, including Information Technology. The UMB and UMBC campuses, with their complementary strengths in Clinical Medicine and Computer Science, will make ideal partners for this training program.

3. Provide a brief narrative of how the proposed program will be adequately funded for at least the first five years of program implementation.

The program will be well-resourced, and will rely on existing faculty at UMB and UMBC, with much of the coursework already developed. Versions of the most courses already exist and will be updated with best practices for online learning in collaboration with UMB's Faculty Center for Teaching and Learning. Because of this, the UMB Graduate School will have the capacity to offer the proposed degree program within existing resources and to ensure continued funding to support the program into the foreseeable future.

4. Provide a description of the institution's a commitment to ongoing administrative, financial, and technical support of the proposed program and continuation of the program for a period sufficient to allow enrolled students to complete the program:

The UMB Graduate School has an ongoing commitment to sustaining new degree programs it has developed. The Graduate School has committed significant resources in

the realm of administrative support including a vice dean, assistant dean, and program director who will provide leadership for the quality and sustainability of the Master of Science in Clinical Informatics. Additionally, leadership within the UMBC Department of Computer Science and Electrical Engineering and leadership within the UMBC Professional Studies in Data Science have expressed their commitment to this proposed program. Helping to manage this collaboration will be Dr. Michael Grasso at UMB and Dr. Anupam Joshi at UMBC. Dr. Grasso is a practicing physician in the Department of Emergency Medicine and a board-certified Clinical Informaticist. He is also a Ph.D. Computer Scientist, who completed this training at UMBC. Dr. Joshi is also a Ph.D. Computer Scientist, Chair of the Department of Computer Science and Electrical Engineering, and is an active member of the UMB ICTR research group. Dr. Ergun Simsek, program director of the UMBC Professional Studies in Data Science program, will provide additional leadership. Drs. Grasso and Joshi have worked together for the past 20 years on various research grants, educational activities, and peer-reviewed publications.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan:

The 2017-2021 Maryland State Plan articulates three primary goals for postsecondary education: access, success, and innovation. The proposed M.S. in Clinical Informatics aligns well with the State Plan.

- Access – The proposed program ensures equitable access. Placing the bulk of the program online offers non-traditional students as well as those not geographically located in the Baltimore a pathway to completing the program. The format also allows them to balance their educational objectives with competing demands of family and work.
- Success – Programs such as this one are expected to attract students from diverse backgrounds originating both locally and internationally. UMB has a full-service student support model to ensure early identification of students who may be struggling academically and to intervene to improve the likelihood of graduate school completion.
- Innovation – The curriculum focuses on the new and innovating area of Clinical Informatics, with immersion experiences that provide hands-on experiences with real-world challenges. For those who qualify, it can also lead to eligibility in the Clinical Informatics subspecialty as well as a Fellow of the American Medical Informatics Association.

The program curriculum will also address bias, equity, and social determinants of health. Disparity is an important challenge in the delivery of healthcare, and as such, it carries over into clinical information systems and decision-support algorithms. Big data analytics and machine learning approaches are especially susceptible to unintended bias, which can lead to discriminatory or exclusionary practices. Bias, equity, and social determinants of health are included in the curriculum objectives under “Fundamentals” and “Clinical Decision Making and Care Process Improvement,” and are incorporated into the Foundations in Clinical and Health Informatics course and the Clinical Decision Support Systems in Healthcare course.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State:

At UMB and UMBC, we regularly receive inquiries about Clinical Informatics training for healthcare professionals, including training leading to board-eligibility and fellow accreditation. The existing UMBC Professional Studies in Data Science program with which we will collaborate has roughly 200 active students, and continues to grow. Clinical Informatics is a rapidly growing interdisciplinary field, which applies biomedical data, process improvement, and information technology to the delivery of healthcare. The U.S. Bureau of Labor Statistics predicts a growth rate of more than 8% in employment opportunities over the next 10 years (<https://www.bls.gov/>), with many related health informatics jobs on the rise (<https://www.monster.com/career-advice/article/health-informatics-jobs>), and with the demand especial high in the Baltimore-Washington region (<https://www.transparencymarketresearch.com/healthcare-informatics-market.html>).

The critical role of health professionals trained in informatics is recognized as integral to the success of our national health agenda. The amount of clinical data that is now available from health record systems is larger than healthcare providers have ever dealt with. National policy, including the Health Information and Technology for Economic Clinical Health Act (HITECH) and Health Insurance Portability and Accountability Act (HIPAA) have imposed important requirements and incentives on healthcare providers with respect to electronic health records. Physicians, nurses, pharmacists, scientists, and researchers trained in informatics are uniquely equipped to direct optimal implementation of health information technology for clinical care delivery and continuous quality improvement. Expansion of the health informatics workforce and development of leadership at local and national levels are priorities for our national healthcare system. The demand for informatics expertise will only grow as our healthcare system continues to evolve.

D. Reasonableness of Program Duplication

No programs exist in Maryland or Washington D.C. that offer a Master's Degree in Clinical Informatics and which also leads to board-eligibility for physicians in Clinical Informatics. The closest programs are at the University of Virginia (ACGME Program #3225132001) and the Children's Hospital of Pennsylvania (ACGME Program #3224132001).

We are aware of other local Health Informatics programs. In the USM, UMBC has a Masters of Professional Studies in Health Information Technology, although it does not have a clinical focus. Johns Hopkins University offers an applied and research Master's Degree in Health Science Informatics, as well as a PBC in Clinical Informatics, but these programs have a more scientific or research emphasis, and lack an option for board-eligibility. George Washington University offers a Biomedical Informatics program, which has an emphasis on epidemiology and genomics, and does not lead to board-eligibility. Morgan State University offers an excellent Bioinformatics program, with a specific emphasis on Computational Biology, which focuses more on genetics and not on the application of Informatics for the delivery of healthcare. University of Maryland Global Campus offers a program with a focus on Health Administration.

UMBC offers a Professional Studies in Data Science graduate program, which we will collaborate with, and which will provide some courses for this new program. The Professional Studies in Data Science program provides an excellent foundation in Computer Science, which we will augment with courses on healthcare fundamentals, clinical decision support, clinical process improvement, and practicums.

E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)

The proposed program does not have relevance to the uniqueness and/or institutional identities and missions of HBIs.

F. Relevance to the identity of Historically Black Institutions (HBIs)

The proposed program does not have relevance to the identity of HBIs in Maryland.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

1. Describe how the proposed program was established, and also describe the faculty who will oversee the program.

The Clinical Informatics program was proposed by the UMB faculty. A series of meetings were held by Dr. Flavius Lilly and Dr. Mary Jo Bondy, and included more than a dozen representatives from the School of Medicine, School of Nursing, School of Pharmacy, School of Law, and School of Social Work. The group recognized the compelling need for specific education and training in Clinical Informatics that was focused on the practice of medicine and improved clinical outcomes.

The faculty realized that many of the courses required to offer this program already existed (or existed but required updates) at UMB and UMBC, and that there was considerable expertise to create a world-class educational experience for students. All of the Professional Studies in Data Science courses already exist and are currently being taught. The CLIN 601, 602, and 604 already exist, and have been taught in the past, but need to be updated.

The faculty overseeing the program are listed with their credentials in Section I, subsection 1: Adequacy of Faculty Resources.

2. Describe educational objectives and learning outcomes appropriate to the rigor, breadth, and (modality) of the program.

By the completion of the proposed M.S. in Clinical Informatics, students will develop core competencies in four key areas: foundations and theory, clinical decision making and care process improvement, health information systems, and leadership and change management, as defined by the American Medical Informatics Association

(<https://www.amia.org/sites/amia.org/files/AMIA-Clinical-Informatics-Core-Content.pdf>).

- Foundations and Theory – At the end of this program, students will have basic knowledge that provides health informaticians with a common vocabulary and understanding of the environment in which they function. Students will be able to:
 - Describe the key concepts of Clinical Informatics, Nursing Informatics, Pharmacy Informatics, and Clinical Research Informatics.
 - Analyze key concepts, models, and theories of informatics.
 - Understand ethics, professionalism, legal, equity and social determinants of health, and regulatory issues.
 - Describe the key concepts of the health system, including organizational structures, the delivery of care, economics, policy.
 - Analyze quality improvement efforts regarding safety, effectiveness, efficiency, patient-centeredness, timeliness, and equity.
- Clinical Decision Making and Care Process Improvement – At the end of the program, students will understand the knowledge and skills that enable a health informatician to implement effective clinical decision-making systems and participate in the development of clinical processes that support effective, efficient, safe, timely, equitable, and patient-centered care. Students will be able to:
 - Understand the nature and cognitive aspects of human decision making.
 - Analyze various decision science approaches, including decision analysis, probability theory, advanced modeling, and cost-effective analysis.
 - Apply decision science using various approaches, understanding various users of these approaches, evaluating their effectiveness, and understanding legal, regulatory, quality, and safety issues.
 - Understand evidence-based medicine, evidence sources, evidence grading, implementation of guidelines, and information retrieval and analysis.
 - Analyze methods for clinical workflow analysis, redesign, and process improvement.
 - Understand the existence of bias in decision support algorithms, and apply methods for identifying and addressing bias in decision-support systems.
- Health Information Systems - At the end of the program, students will understand the knowledge and skills that enable a health informatician to participate in the development or selection of an information system for clinicians; prepare clinicians prior to implementation and support them during implementation and ongoing operation of a clinical information system; and evaluate the effectiveness of a system in meeting clinical needs. Students will be able to:

- Understand computer systems, including programming, control structures, data structures, software development methods, computing architectures, networking, security, data management, data manipulation, and data sharing.
- Analyze approaches to human factors engineering.
- Critically evaluate health information systems applications by type of functionality, setting where systems are used, telehealth capabilities, and relationship to the electronic health record.
- Understand the system lifecycle, including governance, analysis, implementation, testing, evaluation, training, maintenance, and evolution.
- Apply computing techniques to develop and validate software components and data artifacts.
- Leadership and Managing Change - At the end of the program, students will understand the knowledge and skills that enable clinical informaticians to lead and manage changes associated with implementing clinical information systems and promoting adoption by health professionals. Students will be able to:
 - Understand the dimensions of effective leadership, including governance, negotiation, conflict management, and motivation.
 - Build effective of interdisciplinary leadership teams and communication strategies.
 - Evaluate organizational structures, behavior, and change theory.

3. Explain how the institution will provide for assessment of student achievement of learning outcomes in the program and document student achievement of learning outcomes in the program.

Faculty will assess student achievement and mastery of learning outcomes in their courses using a variety of assessments including meaningful and substantive contributions to online course discussions, satisfactory completion of assignments and reflections, scores on quizzes and examinations, scores on team collaboration, scores on written essays and term papers, and evaluation of research and capstone project contribution to the field of Clinical Informatics.

Students will also have the opportunity to evaluate courses and faculty through a standard evaluation of every course. Formal assessment planning is already in place throughout UMB Schools including the Graduate School. Our approach includes ensuring that student learning is in alignment with course learning outcomes, alignment of mission at institutional and program levels, alignment of mission with learning outcomes, then program outcomes with curriculum, flowing down to course outcomes and assignments. Assessment activities emphasize analysis of results and feedback loops for continuous improvement. Additional evaluation includes tracking of student retention, grade distributions, and cost-effectiveness, and regular academic program reviews consider these factors.

4. Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements

Students must complete the following 4 core courses at UMB (12 credits) to complete a PBC in Clinical Informatics (proposal forthcoming from UMB), 3 courses (10 credits) in practical activities at UMB, and an additional 4 courses at UMBC (12 credits) to complete a PBC of Professional Studies in Data Science, for a total of 34 program credits.

Course Name	UMB PBC Clinical Informatics	UMBC PBC Professional Studies in Data Science	UMB Practical Courses
CLIN 601 Foundations in Clinical and Health Informatics	X		
CLIN 602 Advanced Foundations in Clinical and Health Informatics	X		
CLIN 603 Computer Programming for Healthcare Personnel	X		
CLIN 604 Decision Support Systems in Healthcare	X		
CLIN 610 Clinical Informatics Practicum			X
CLIN 611 Advanced Clinical Informatics Practicum			X
CLIN 612 Clinical Informatics Conference			X
DATA 601 Introduction to Data Science		X	
DATA 602 Introduction to Data Analysis and Machine Learning		X	
DATA 603 Platforms for Big Data Processing		X	
DATA 604 Data Management		X	

PBC Clinical Informatics Courses, 12 credits (UMB, proposal forthcoming)

- CLIN 601 Foundations in Clinical and Health Informatics (3 credits)

This course will cover the fundamentals of informatics as it applies to healthcare and research. The course focuses on the expanding role of information technology for the delivery of healthcare, and provides a theoretical and practical introduction to the assessment, implementation, and management of these systems. The course underscores the application of these systems to the practice of medicine, in order to enhance health outcomes, improve patient care, and strengthen the clinician-patient relationship. Topics will emphasize the clinical informatics board-certification core content, which include fundamentals of clinical and biomedical informatics, clinical decision making and process improvement, health information systems, equity and social determinants of health, and management.

- CLIN 602 Advanced Foundations in Clinical and Health Informatics (3 credits)

This course will cover advanced concepts of informatics as it applies to healthcare and research, with a focus on critical thinking skills. The course is the second of a

two-part series of courses in Clinical Informatics. The focus of the course will be on the software engineering and socio-technical challenges specific to the design, development, validation, and implementation of these systems. Topics will include clinical software engineering, continuous process improvement, decision support systems, bioinformatics, public health informatics, telehealth, clinical imaging systems, personalized medicine, and health informatics literature.

- CLIN 603 Computer Programming for Healthcare Personnel (3 credits)

This course will provide an introductory overview of computer science and programming for students who are not working in technology-based professions. This course is meant for beginners, with no prior experience in computer programming, and is meant to introduce healthcare professionals to the fundamentals of computer programming and information systems. Topics include fundamental programming concepts, fundamental data structures, scripting languages, web-based systems, algorithm design, database design, human factors, and software lifecycles.

- CLIN 604 Decision Support Systems in Healthcare (3 credits)

This course will give students an overview of information systems and decision systems used in health organizations. The course will examine the design, development, and implementation of decision support systems, focusing on how they fit into clinical workflows across various healthcare settings. Students will examine the analytical foundations of these systems, identify areas that might benefit from these systems, and gain an understanding in the challenges surrounding their implementation. Topics include decision support, evidence-based care, process improvement, privacy and security, unintended bias, database analysis and design, and data and information flow.

Practical Courses, 10 credits (UMB)

- CLIN 610 Clinical Informatics Conference (1 credits)

This course will give students the opportunity to discuss and learn about important issues in the use of information technology to improve patient care. The conference meets monthly each semester, *with students required to enroll for a minimum of 4 semesters to complete the M.S. in Clinical Informatics*. Activities in the conference include grand rounds, journal club, and board review activities. Student can join the conference in-person or online.

- CLIN 611 Clinical Informatics Practicum (3 credits)

This course will give students the ability to demonstrate the knowledge and skills that have been acquired, with a focus on data collection, project management, and presentation skills. Students will be embedded in an informatics setting within the University of Maryland Medical System, work with interdisciplinary teams to address significant informatics challenges in both clinical and academic settings. As an alternative to embedding students on-site at the University of Maryland, distance-learning students can work online to develop a proposal and perform independent work under the supervision of an advisor.

- CLIN 612 Advanced Clinical Informatics Practicum (3 credits)

This course will give advancing students the ability to demonstrate substantive application of the knowledge and skills that have been acquired, with a focus on performing independent research. Students will be embedded in an informatics setting within the University of Maryland Medical System or an academic setting within the University of Maryland. As an alternative to embedding students on-site at the University of Maryland, distance-learning students can work online to develop a proposal and perform independent work under the supervision of an advisor.

Professional Studies in Data Science Courses, 12 credits (UMBC)

- DATA 601 Introduction to Data Science (3 credits)

The goal of this class is to give students an introduction to and hands on experience with all phases of the data science process using real data and modern tools. Topics that will be covered include data formats, loading, and cleaning; data storage in relational and non-relational stores; data analysis using supervised and unsupervised learning using Python; data visualization; and scaling up for Big Data.

- DATA 602 Introduction to Data Analysis and Machine Learning (3 credits)

This course provides a broad introduction to the practical side of machine-learning and data analysis. Topics covered include decision trees, logistic regression, linear discriminant analysis, linear and nonlinear regression, basic functions, support vector machines, neural networks, ensemble methods, evaluation methodologies, experiment design, and Bayesian networks.

- DATA 603 Platforms for Big Data Processing (3 credits)

The goal of this course is to introduce methods, technologies, and computing platforms for performing data analysis at scale. Topics include the theory and techniques for data acquisition, cleansing, aggregation, management of large heterogeneous data collections, processing, information and knowledge extraction.

Students are introduced to map-reduce, streaming, and external memory algorithms and their implementations using Hadoop and its eco-system (HBase, Hive, Pig and Spark). Students will gain practical experience in analyzing large existing databases.

- DATA 604 Data Management (3 credits)

This course is specifically designed to support the range of complex data challenges data practitioners face today from optimizing relational database systems to managing big data. Students will get an overview of relational database management systems, SQL programming, and emerging big data technologies. Advanced topics include parallel and GPU computing using expert driven course materials and hands on labs from Nvidia.

4. Discuss how general education requirements will be met, if applicable.

Not applicable.

5. Identify any specialized accreditation or graduate certification requirements for this program and its students.

There are no specialized accreditation or graduate certification requirements for the proposed M.S. in Clinical Informatics.

6. If contracting with another institution or non-collegiate organization, provide a copy of the written contract.

There is a Memorandum of Understanding between UMB and UMBC (Appendix B)

7. Provide assurance and any appropriate evidence that the proposed program will provide students with clear, complete, and timely information on the curriculum, course and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and costs and payment policies.

The Graduate School maintains up-to-date information of its degree programs on the program explorer web site (<https://www.graduate.umaryland.edu/Program-Explorer/>). The web site has information on the curriculum, course descriptions, degree requirements, and cost of education. The website has links to information about the learning management system, support services, and financial aid. We affirm that the same information will be available for prospective and existing students in the proposed M.S. in Clinical Informatics.

8. Provide assurance and any appropriate evidence that advertising, recruiting, and admissions materials will clearly and accurately represent the proposed program and the services available.

The Graduate School at UMB affirms that all advertising, recruiting and admissions materials will accurately represent the M.S. in Clinical Informatics, as do all materials produced by UMB's Graduate School for programs it offers.

H. Adequacy of Articulation

Not applicable.

I. Adequacy of Faculty Resources

1. Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of faculty with appointment type, terminal degree title and field, academic title/rank, status (full-time, part-time, adjunct) and the course(s) each faculty member will teach in the proposed program.

The following table summarizes information about the faculty who will be responsible for designing and instructing coursework in the M.S. in Global Health program:

Name	Terminal Degree and Discipline	Rank and FT/PT Status	Course
UMB Faculty			
Michael Grasso	MD, PhD, Medicine, Computer Science	Assistant Professor, FT	Foundations in Clinical and Health Informatics, Advanced Foundations in Clinical and Health Informatics, Clinical Informatics Conference
Jon Mark Hirshon	MD, PhD, Medicine, Epidemiology	Professor, FT	Decision Support Systems in Healthcare
Dan Lemkin	MD, Medicine	Assistant Professor, FT	Advanced Clinical Informatics Practicum
Zachary Dezman	MD, MS, Medicine, Epidemiology	Assistant Professor, FT	Clinical Informatics Practicum
Mark Sutherland	MD, Medicine	Assistant Professor, FT	Clinical Informatics Practicum
UMBC Faculty			
Anupam Joshi	PhD, Computer Science	Professor, FT	Concepts in Computer Programming for Healthcare Personnel
Ergun Simsek	PhD, Computer Science	Professor, FT	Data 601 Introduction to Data Science

Murat Guner	PhD, Computer Science	Lecturer, PT	Data 602 Introduction to Data Analysis and Machine Learning
Waleed Youssef	PhD, Computer Science	Lecturer, PT	Data 603 Platforms for Big Data Processing
Patricia Stanton	PhD, Computer Science	Lecturer, PT	Data 604 Data Management

In addition to those listed above, the following faculty have also expressed a desire to help develop this program.

- Fadia Shaya, PhD, MPH, School of Pharmacy
- Bimbola Akintade, PhD, MBA, ACNP-BC, School of Nursing
- Eun-Shim Nahm, PhD, RN, School of Nursing
- Rick Barth, PhD, MSW, School of Social Work
- Jeff Fink, MD, School of Medicine
- John Hong, MD, School of Medicine
- Lee-Ann Wagner, MD, School of Medicine

2. Demonstrate how the institution will provide ongoing pedagogy training for faculty in evidenced-based best practices, including training in:

UMB has a robust process for training faculty and ensuring effective instruction. Based on Quality Matters standards, UMB developed a rubric which details the best practices for distance education; this rubric helps faculty and instructional designers create the courses; assesses the readiness of the course and ensures that the online courses are instructionally and pedagogically sound. The best practices are a synthesis of strategies, activities, design techniques, and organizational items that have been successful in higher education. The specific domains of this checklist are as follows:

- Course overview and introduction to the students
- Course organization and design
- Learning Objectives (competencies)
- Instructional Materials
- Learner Communication, Interaction and Collaboration
- Assessment and Evaluation (measurement)
- Course Technology
- Learner Support

The Learning Management Platform UMB utilizes and provides IT support for is the Blackboard Learning Management System for online course delivery. Within Blackboard, is the Collaborate conferencing software that we will use for our synchronous live activities, i.e., orientation and presentation face-to-face class sessions and recurring webinars. Additionally, the Faculty Center for Teaching and Learning

which houses expert Instructional and Educational Media Specialists, uses of a video camera to record lectures, integrate webcams, and an interactive smart board. We also use the Camtasia software for screen lecture capture.

J. Adequacy of Library Resources

The University of Maryland, Baltimore's Health Sciences and Humans Services Library (HS/HSL) collection contain more than 30,000 electronic journals, 162 current print journals, approximately 170,000 books, and 6,000 electronic books. Students can access the electronic resources offered on the library website by logging in with their University ID number. The library serves as the regional medical library for ten southeastern states as part of the National Library of Medicine's National Network of Libraries of Medicine. In addition to the library services and collections, the building also houses computing services. Faculty librarians are dedicated to providing direct service to students. They use subject expertise to develop online resources and provide in-person consultations.

The HS/HSL is one of the largest health sciences libraries in the United States with a track-record of user-centered innovative services and programs. The library consists of 57 employees including 27 faculty librarians. The attractive and vibrant facility, which opened in 1998, serves as a hub for collaboration and learning with resources, programs, and tools that promote discovery, creativity, and innovation. With wireless connectivity throughout the building, the HS/HSL has 45 group study rooms, three computer classrooms, an Innovation Space which includes 3D printers; a presentation and practice studio, art gallery, and multiple technology enhanced meeting spaces. Through the HS/HSL's website (www.hshsl.umaryland.edu), the UMB community has access to a full range of resources and services.

The HS/HSL supports the University's students, faculty, and staff members in the schools of dentistry, law, medicine, nursing, pharmacy, and social work; the Graduate School; the University of Maryland Medical Center; and other affiliated institutions. Research Connection, the library's suite of research services, is available for all programs on campus and includes individual research consultations, a systematic review service, research impact assessment, reference assistance, and more. For over 30 years, the HS/HSL has provided liaison services, in which faculty librarians are assigned to work with specific user communities. Faculty librarians have many years of instructional experience in the classroom, in the community, and the online environment. In FY16, faculty librarians reached 4,131 faculty, staff and students through online and in-person instructional sessions offered through the curriculum and in library-sponsored workshops.

In FY16, the HS/HSL licensed 116 databases, 4,524 journals, 18,018 e-books, and maintained a print collection of 360,104 volumes. One hundred percent of the current journal subscriptions are available electronically. Through its interlibrary loan and document delivery service, library staff can acquire articles and other resources not available through the library's collections. These are secured through local, regional, and national networks including the University System of Maryland and Affiliated Institutions, the National Library of Medicine's DOCLINE service, and OCLC, among others. The HS/HSL is also home to the National Network of Libraries of Medicine/Southeastern Atlantic Region (NNLM/SEA), whose mission is to advance the progress of medicine and improve the public health by providing all U.S. health professionals with equal

access to biomedical information and improve the public's access to information to enable them to make informed decisions about their health. With only eight regions in the U.S. designated as regional medical libraries under contract to the National Library of Medicine at the National Institutes of Health, the Southeastern/Atlantic Region serves ten southeastern states, Puerto Rico, the U.S. Virgin Islands, and the District of Columbia. The HS/HSL has held this competitive and prestigious designation for over 30 years.

K. Adequacy of Physical Facilities, Infrastructure, and Instructional Equipment

UMB's 71-acre research and technology complex encompasses 67 buildings in west Baltimore near the Inner Harbor. Faculty have offices provided within their respective departments and the Graduate School has identified office space to house the Program Manager Specialist and instructional technology personnel. UMB has adequate facilities, infrastructure and equipment to support any distance learning needs of the Master's Program. Students will have full access to the computing facilities at UMB. Students will be provided with UMB e-mail and library accounts and will have complete journal searching ability via PubMed. UMB possesses computing facilities that includes a networked computing environment for support of a broad range of information technology functions, including basic research, clinical research, patient information and general office management.

L. Adequacy of Financial Resources with Documentation

No new general funds will be required for implementation of the proposed MS and PBC which will be coordinated and administered fully through the Graduate School. A budget is included in Appendix A.

M. Adequacy of Provisions for Evaluation of Program

Students will have the opportunity to evaluate courses and faculty through a standard evaluation of every course. Formal assessment planning is already in place throughout UMB Schools including the Graduate School. Our approach includes ensuring that student learning is in alignment with course learning outcomes, alignment of mission at institutional and program levels, alignment of mission with learning outcomes, then program outcomes with curriculum, flowing down to course outcomes and assignments. Assessment activities emphasize analysis of results and feedback loops for continuous improvement. Additional evaluation includes tracking of student retention, grade distributions, and cost-effectiveness, and regular academic program reviews consider these factors.

N. Consistency with the State's Minority Student Achievement Goals

UMB is strongly committed to cultural diversity and the recruitment and retention of underrepresented minority students. Recruitment efforts for the M.S. in Clinical Informatics will include specific outreach to Historically Black Institutions to make students aware of the

program and related opportunities designed to improve their competitiveness in the job market and reach their professional goals if they are admitted and successfully complete the program.

O. Relationship to Low Productivity Programs Identified by the Commission

The proposed MS is not directly related to an identified low productivity program identified by the Maryland Higher Education Commission.

P. Adequacy of Distance Education Programs

Context of Online Education at UMB

As the State's public health, law, and human services university, the mission of UMB is to excel at professional and graduate education, research, patient care, and public service, and to educate leaders in healthcare delivery, biomedical science, global health, social work and the law. Also, UMB emphasizes interdisciplinary education in an atmosphere that explicitly values civility, diversity, collaboration, and accountability. UMB expects to achieve its mission in education excellence and to be competitive; the Graduate School has designed and offered online degree programs that respond to the following changes occurring in higher education (Allen, 2010).

1. **Education Pipeline.** The education pipeline includes a highly diverse prospective applicant pool. Prospective students are typically working adults who pursue part-time and non-residential educational opportunities, but who wish to remain in their regional geographic area, while pursuing advanced education. According to the National Center for Education Statistics, National Postsecondary Graduate Student Aid Study (NCES, NPSAS: GR; 2017), between the period of 2008 and 2017, there was a slight increase (3%) in the number of graduate students reporting full-time (FT) enrollment at a single institution. We suspect this may be partially influenced by availability of new online educational programs, where one can work, be considered enrolled FT, yet negotiate academic studies as one's lifestyle permits.
2. **Changing Demographics.** Data indicate a shift from the traditional student (the 18-22-year-old, full-time resident) to older students studying part-time. In 2015-2016, the National Center for education Statistics (NCES, 2017) reported that 37.58% of graduate students were married and the average graduate student was 32 years old ($SD= 9.66$). Nearly 9% of single/unmarried/divorced graduate students reported dependents, and nearly 60% of graduate students were female.
3. **Technology Shift.** Educational research suggests that online education achieves the same as, or better student learning outcomes, than traditional

face-to-face delivery models (Tallent-Runnels, et al., 2006; Means et al., 2009). Online delivery is far outpacing traditional forms of educational delivery. Between 2002 to 2008, online enrollments grew at an annual rate of 19% vs. 1.5% versus all of Higher Education. By the fall of 2008, 25% (4.6 million) of all students took at least one online course. In 2019, the top five highest reported college enrollments nationally four were online universities, offering at least some graduate programs (NCES).

4. **Growth of Mobile Technologies.** Mobile technologies and miniaturization are changing the computing environment and the educational delivery paradigm. Technologies like netbooks, e-Readers, iPhones and iPads have revolutionized the delivery space and to provide anywhere, anytime learning.
5. **Web 2.0 Revolution.** Other technologies that are already figuring widely into the future of education are part of the Web 2.0 revolution. The use of a variety of technologies is disaggregating the educational experience into 'the cloud'. Many of the technologies for the future, like blogs, wikis, podcasts, video, social networking and social media, virtual worlds, mobile learning, and Personal Learning environments, will have profound effects on the future learning landscape.

Essentially, online education represents a strategy that can address the restrictions of traditional onsite college courses, opening up accessibility for variety of learners, for a variety of reasons and expanding access to global education opportunities and expertise, beyond the walls of the campus. Major determinants of successful online programs include 1) course design that incorporates best practices (e.g. course alignment, integration of technology and content), 2) quality faculty who can engage students in the material (e.g. provide feedback and relevant expertise), and 3) provide responsible academic oversight. All three of these determinants are present in this proposal.

Collectively, the distance learning team will provide the following services to ensure that best pedagogical practices are used to train and support the most of effective presentation of their course content.

- Guided tutorials on the online course development process, with open questions and answer session.
- Written instructions accompanied by training videos to guide faculty on how to use the learning management system.
- A manual for the faculty regarding principles of good practice and the pedagogy of distance education.

- Provide timely support to the faculty in the use of the technology and trouble shoot any problems that might arise during the course of instruction.
- Work with faculty to design and develop courses, monitor the delivery of the course, and assess and revise the course for future offerings.

Supporting Students in Distance Education

All of the courses for the M.S. in Clinical Informatics will be online. Students enrolled in the practicum courses will have the option of working on-site or online. We realize that the key to the success of the online courses is dependent on a) students knowing upfront the assumptions, requirements and responsibilities of taking an online course, 2) the ability of students to have the background, knowledge, and technical skills to undertake an online program; and 3) their having access to academic and technical support services to support their online activities. Accordingly, we will provide the following services to support the students in accessing distance learning technology:

- Communicate to students the nature of online learning, including their requirements, roles and responsibilities, and access to support services. All of our advertising, recruiting, and admissions materials shall clearly and accurately represent the program and the services available.
- Ensure that enrolled students shall have reasonable and adequate access to the range of student services to support their learning.
- Ensure that accepted students will have the background, knowledge, and technical skills needed to undertake the program.
- Make available the library Services to students so that they can have access to research databases, online catalog of books and media, chat with or e-mail a Librarian, electronic interlibrary loan, and more.

Evaluation and Assessment of Online Courses

We will adhere to a quality improvement model for assuring the continuous quality of the online courses. The process will involve the following steps:

1. Assessment of course readiness as measured by our quality indicators of best practices (including assessment of faculty readiness)
2. Monitoring of course delivery as assessed by the instructional designers with use of our “course evaluation’ rubric”
3. Obtainment of feedback from the faculty and students and instructional designers.
4. Analysis of feedback as performed by the Distance Learning Committee.

5. Institute course revisions based on comments by the Distance Learning Committee.

Finally, to ensure the sustainability of the distance learning program, the Academic Affairs Office at UMB affirms the following:

- UMB Policies for faculty evaluation includes appropriate consideration of teaching and scholarly activities related to programs offered through distance learning.
- Commitment to ongoing support, both financial and technical, and to a continuation of the program for a period sufficient to enable students to complete a certificate

APPENDIX A: BUDGET

TABLE 1: PROGRAM RESOURCES					
Resource Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Reallocated Funds	0	0	0	0	0
2. Tuition/Fee Revenue (c +g below)	\$69,878	\$158,390	\$201,948	\$247,184	\$252,128
a. Number of F/T Students*	0	0	0	0	0
b. Annual Tuition/Fee Rate	\$0	\$0	\$0	\$0	\$0
c. Total F/T Revenue (a x b)	0	0	0	0	0
d. Number of P/T Students	9	20	25	30	30
e. Credit Hour Rate	\$706	\$720	\$734	\$749	\$764
f. Average Annual Credit Hours	11	11	11	11	11
g. Total P/T Revenue (d x e x f)	\$69,878	\$158,390	\$201,948	\$247,184	\$252,128
3. Grants, Contracts & Other External Sources	\$0	\$0	\$0	\$0	\$0
4. Other Sources*	\$69,342	\$0	\$0	\$0	\$0
TOTAL (Add 1 – 4)	\$139,220	\$158,390	\$201,948	\$247,184	\$252,128

*Other UMB Graduate School Tuition revenue

TABLE 2: PROGRAM EXPENDITURES:					
Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Faculty (b + c below)	\$94,900	\$108,400	\$118,845	\$150,120	\$162,630
a. Number of FTE	0.80	0.90	0.90	1.10	1.10
b. Total Salary	\$78,300	\$90,400	\$95,000	\$120,000	\$130,000
c. Total Benefits	\$16,600	\$18,000	\$23,845	\$30,120	\$32,630
2. Admin. Staff (b + c below)	\$19,320	\$9,660	\$4,830	\$4,830	\$4,830
a. Number of FTE	0.2	0.1	0.05	0.05	0.05
b. Total Salary	\$14,000	\$7,000	\$3,500	\$3,500	\$3,500
	\$5,320	\$2,660	\$1,330	\$1,330	\$1,330
3. Support Staff (b + c below)	\$7,590	\$7,742	\$7,896	\$8,055	\$8,215
a. Number of FTE	0.1	0.1	0.1	0.1	1.1
b. Total Salary	\$5,500	\$5,610	\$5,722	\$5,837	\$5,953
c. Total Benefits	\$2,090	\$2,132	\$2,174	\$2,218	\$2,262
4. Technical Support and Equipment	\$5,000	\$2,000	\$2,000	\$2,000	\$2,000
5. Library	0	\$5,000	\$5,000	\$5,000	\$5,000
6. New or Renovated Space	0	0	0	0	0
7. Other Expenses	\$20,000	\$10,000	\$10,000	\$10,000	\$10,000
TOTAL (Add 1 – 7)	\$139,220	\$135,060	\$140,675	\$171,950	\$184,460

APPENDIX C: PLAN OF STUDY

Full-Time Plan of Study, Fall Start

Semester	Course	Credits	CI PBC (UMB)	DS PBC (UMBC)	P (UMB)
Year 1					
Fall A	CLIN 601 Foundations in Clinical and Health Informatics	3	X		
Fall B	CLIN 602 Advanced Foundations in Clinical and Health Informatics	3	X		
Fall A/B	DATA 601 Introduction to Data Science	3		X	
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Spring A	CLIN 603 Computer Programming for Healthcare Personnel	3	X		
Spring B	CLIN 604 Decision Support Systems in Healthcare	3	X		
Spring A/B	DATA 602 Introduction to Data Analysis and Machine Learning	3		X	
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Year 2					
Fall A/B	DATA 603 Platforms for Big Data Processing	3		X	
Fall A	CLIN 611 Clinical Informatics Practicum	3			X
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Spring A/B	DATA 604 Data Management	3		X	
Spring B	CLIN 612 Advanced Clinical Informatics Practicum	3			X
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X

Full-Time Plan of Study, Spring Start

Semester	Course	Credits	CI PBC (UMB)	DS PBC (UMBC)	P (UMB)
Year 1					
Spring A	CLIN 603 Computer Programming for Healthcare Personnel	3	X		
Spring B	CLIN 604 Decision Support Systems in Healthcare	3	X		
Spring A/B	DATA 601 Introduction to Data Science	3		X	
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Fall A	CLIN 601 Foundations in Clinical and Health Informatics	3	X		
Fall B	CLIN 602 Advanced Foundations in Clinical and Health Informatics	3	X		
Fall A/B	DATA 602 Introduction to Data Analysis and Machine Learning	3		X	
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Year 2					
Spring A/B	DATA 603 Platforms for Big Data Processing	3		X	
Spring A	CLIN 611 Clinical Informatics Practicum	3			X
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Fall A/B	DATA 604 Data Management	3		X	
Fall B	CLIN 612 Advanced Clinical Informatics Practicum	3			X
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X

Part-Time Plan of Study, Fall Start

Semester	Course	Credits	CI	DS	P
Year 1					
Fall A	CLIN 601 Foundations in Clinical and Health Informatics	3	X		
Fall B	CLIN 602 Advanced Foundations in Clinical and Health Informatics	3	X		
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Spring A	CLIN 603 Computer Programming for Healthcare Personnel	3	X		
Spring B	CLIN 604 Decision Support Systems in Healthcare	3	X		
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Year 2					
Fall A/B	DATA 601 Introduction to Data Science	3		X	
Fall A/B	DATA 602 Introduction to Data Analysis and Machine Learning	3		X	

Spring A/B	DATA 603 Platforms for Big Data Processing	3		X	
Spring A/B	DATA 604 Data Management	3		X	
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Year 3					
Fall A	CLIN 611 Clinical Informatics Practicum	3			X
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Fall B	CLIN 612 Advanced Clinical Informatics Practicum	3			X

Part-Time Plan of Study, Spring Start

Semester	Course	Credits	CI	DS	P
Year 1					
Spring A	CLIN 603 Computer Programming for Healthcare Personnel	3	X		
Spring B	CLIN 604 Decision Support Systems in Healthcare	3	X		
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Fall A	CLIN 601 Foundations in Clinical and Health Informatics	3	X		
Fall B	CLIN 602 Advanced Foundations in Clinical and Health Informatics	3	X		
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Year 2					
Spring A/B	DATA 601 Introduction to Data Science	3		X	
Spring A/B	DATA 602 Introduction to Data Analysis and Machine Learning	1		X	
Fall A/B	DATA 603 Platforms for Big Data Processing	3		X	
Fall A/B	DATA 604 Data Management	3		X	
Fall A/B	CLIN 610 Clinical Informatics Conference	1			X
Year 3					
Spring A	CLIN 611 Clinical Informatics Practicum	3			X
Spring A/B	CLIN 610 Clinical Informatics Conference	1			X
Spring B	CLIN 612 Advanced Clinical Informatics Practicum	3			X