STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA
PROPOSAL FOR ORGANIZATIONAL CHANGE
COVER SHEET

1. Institution Virginia Polytechnic Institute and State University

2. Nature of Proposed Change (i.e., to establish, reorganize, or terminate/close an institutional unit). Please indicate the change here. Attach a detailed description of the change as a separate document. Attach copies of the institution's current and resultant organizational charts.
   Change the name of the Department of Interprofessionalism to Department of Healthcare Innovation and Implementation Science.

3. Purpose of Proposed Change. Please indicate the reason(s) for the change here. Attach a detailed description of the rationale for the change on a separate page.
   The proposed name represents the overall academic content that better reflects the instructional focus.

4. Type of Proposed Change (check one).

SIMPLE ☒	COMPLEX ☐
Please explain how the change fits with the institution's mission, curriculum, and funding on a separate page.	Please complete and submit Part I Supplemental Information and Part II Information for Non-exempt off-campus site.

5. Does this proposed change involve the establishment of an off-campus instructional site?

NO ☒ YES ☐

If yes, does the proposal fit the criteria for a partially-exempt, non-exempt, or fully-exempt instructional site?

PARTIALLY-EXEMPT ☐	NON-EXEMPT ☐	FULLY-EXEMPT ☐
If partially-exempt, please attach documentation to support this status.	If non-exempt, please complete and submit Part II and Part III of this form.	If fully-exempt, please attach documentation to support this status.

6. Date of Approval by Board of Visitors. (MM/DD/YYYY)

☐ Check box if BOV approval is not needed.

7. Proposed Effective Date of Organizational Change.

Signature	Date
Executive Vice President and Provost	540-231-6122
Title	Phone

VTC | Virginia Tech Carilion School of Medicine

2 Riverside Circle
Roanoke, VA 24016
Telephone: (540) 526-2559
Fax: (540) 581-0741
www.vtc.vt.edu

January 25, 2021

Dear Colleagues:

I am writing in support of the proposal requesting approval for the name change of our current "Department of Interprofessionalism" to the "Department of Healthcare Innovation and Implementation Science here at the Virginia Tech Carilion School of Medicine. This name change is being proposed to more accurately describe the department's programs and activities, and to reflect a rapidly growing interest nationwide in the science of health systems and healthcare delivery.

The immediate impetus for this name change request is the fact that our medical school has expanded its curriculum to include new content related to health systems science. Upon my arrival as Dean in July of 2019, one of my priorities was to begin work on this aspect of our curriculum. I appointed a multidisciplinary task force that worked for several months and made specific recommendations to our curriculum governance structure concerning this topic, and the resulting changes in our curriculum are underway. As required by university governance, our Medical Curriculum Committee has endorsed the departmental name change. It has also been vetted extensively among faculty members in the present department as well as the leadership of our school and our partner health system, Carilion Clinic. Further justification and details may be found in the attached summary.

The change of the department name requires a small amount of funding that will be provided by our college; we will request no funding from the university or the state to make the change. Further, the change will not alter the university's mission but rather will support Virginia Tech's commitment to "improving the quality of life and the human condition within the Commonwealth of Virginia and throughout the world" as reflected in our university mission statement.

Thank you for your consideration, and please allow me to answer any additional questions you may have.

Sincerely,

Lee A. Learman, MD, PhD
Dean, Virginia Tech Carilion School of Medicine
2 Riverside Circle, Roanoke, VA 24016
llearman@vt.edu

Table of Contents

Virginia Polytechnic Institute and State University
Organizational Change

Institution

Virginia Polytechnic Institute and State University

Nature of Proposed Change

Virginia Tech proposes permission to change the name of the current Department of Interprofessionalism to the Department of Healthcare Innovation and Implementation Science. This change will be in title only and will not impact organizational structure of the university or the school. This change will not alter the university's mission.

Background

The Department of Interprofessionalism was initially established in 2008 within the private-public partnership between the Virginia Tech Carilion School of Medicine and Virginia Tech. Upon the integration of the Virginia Tech Carilion School of Medicine within Virginia Tech in 2018, the Virginia Tech Carilion School of Medicine (VTCSOM) and subsequently, the Department of Interprofessionalism became part of Virginia Tech.

In the summer of 2020, the learning domain within the Department of Interprofessionalism was updated to reflect more comprehensive and contemporary content. After considering the breadth of the academic content of the program administered by the department, faculty and administrators determined that the name Department of Healthcare Innovation and Implementation Science would better represent the academic programming of the department.

Purpose of Proposed Change

The purpose of the proposed organizational change is to change the name of the department to better reflect the academic programming in the department.

Mission

The proposed organizational change will not alter or change Virginia Tech's mission. The proposed new name aligns with the institution's mission. The proposed name supports Virginia Tech's commitment to "improving the quality of life and the human condition" as part of the programming offered by the department and the institution. The proposed name reflects the "inclusive community of knowledge" of faculty, programs, and students in the department.

Rationale for Proposed Change

The proposed name change is needed and will provide a more accurate description of the department's overall academic content.

Over the past ten years, the field of medical education/physician training has increasingly called for medical schools to educate students regarding various aspects of the health systems in which

they will eventually practice[1]. Such concepts as healthcare structures and processes, health systems finance and operations, value-based care, population and public health, clinical informatics, healthcare policy, health disparities/inequities, leadership and health system improvement have not traditionally been covered as part of the core medical curriculum, but are now being introduced into the curricula of increasing numbers of medical schools nationwide.

To that end, the VTCSOM updated the curricula in the Health Systems Science and Interprofessional Practice learning domain in 2020 to incorporate these concepts into the training received by the students. The proposed name change of the existing academic department at the VTCSOM coincides with this process. Building on its long tradition of interprofessional education in the health sciences, the current learning domain identified as "interprofessional education" will undergo a gradual expansion to include this new content focused on health systems science and interprofessional practice. The nomenclature chosen for the proposed name, i.e., healthcare innovation and implementation science, reflects the new focus on health systems. As applied to healthcare, "innovation" refers to finding new, more effective ways to deliver care and solve problems, resulting in improved health for individuals and communities. Related to healthcare innovation, "implementation science" is the study of methods used to ensure that research findings are effectively translated into clinical care processes, thus ensuring that new medical therapies and/or procedures become available to patients. Thus, the new departmental name will reflect the overall emphasis on health systems science, innovation and implementation science within the revised curriculum.

See Appendix A for a sample list of medical schools with departments and programs that include the expanded curriculum (i.e., health systems science).

Academic Programs

The proposed name change will not impact the curricular offerings of the VTCSOM. The department provides content and programming that is interwoven throughout the four-year curriculum but does not administer stand-alone academic credentials (e.g., degree programs, certificates). No degree programs will relocate to the department as a result of the proposed name change. There will be no changes to the medical degree program as a result of the proposed name change.

The department contributes the following curricular components to the overall medical education:

Introduction to Health Systems Science and Interprofessional Practice
Orientation to Health System Science and Interprofessional Practice and Systems Thinking
Health System Science and Population Health
Health System Science and Healthcare Policy
Health System Science and Leadership in Healthcare Improvement
Health System Science and Professional vs Team Advocacy

---

[1] Gonzalo, J. D., Chang, A., Dekhtyar, M., Starr, S. R., Holmboe, E., & Wolpaw, D. R. (2020). Health Systems Science in Medical Education: Unifying the Components to Catalyze Transformation. *Academic Medicine: Journal of the Association of American Medical Colleges*, *95*(9), 1362–1372. [See Attachment 1]

Health Systems Science and Interprofessional Practice: Teams
Healthcare Roles and Responsibilities/Professional Controversies and Challenges
Team Leadership in Health Care
Longitudinal Experiences in Health Systems Science

Health Systems Science and Interprofessional Practice: Population Health and Healthcare Delivery
Leading Causes of Death
Population-Based Diets & Clinical Nutrition
Social Determinants of Health
Integration of Public Health and Health Care Delivery
Health Care Delivery Systems
Organizational Ethics & Professionalism Issues in Health Systems Science
Medico-Legal Issues in Health Care

Health Systems Science and Interprofessional Practice: Safety and Quality
Clinical Informatics & Health Information Technology
Patient Safety 1
Patient Safety 2
Quality Improvement 1
Quality Improvement 2
Application of Foundational Skills to Health Systems Science
Health Care Team Challenges

Resources/Budget

There will be an initial expenditure of approximately $5,000 to be used for purchasing of stationary, business cards, and marketing costs associated with the proposed name change. This cost will be accommodated by funds presently available to the medical school as a result of cost savings within the travel budget accrued during the 2019-2020 academic/budget year.

Print materials (stationary, business cards)	$2,500
Marketing and publicity	$2,500
Total	**$5,000**

No additional expenses are required to implement the proposed name change. No new positions will be needed to implement the name change. Departmental administration, administrative support, and space will not be changed by the proposed name change. Changes to the website will be completed during the normal course of business as internal updates are completed. There are no signage costs associated with the proposed name change as departments do not have individual signage. Virginia Tech and the Virginia Tech Carilion School of Medicine have adequate and sufficient resources for the proposed organizational change to change the department's name. No new resources will be requested from the state to initiate or sustain the organizational change to rename the Department of Interprofessionalism.

Appendix B presents the existing organizational structure of the School.

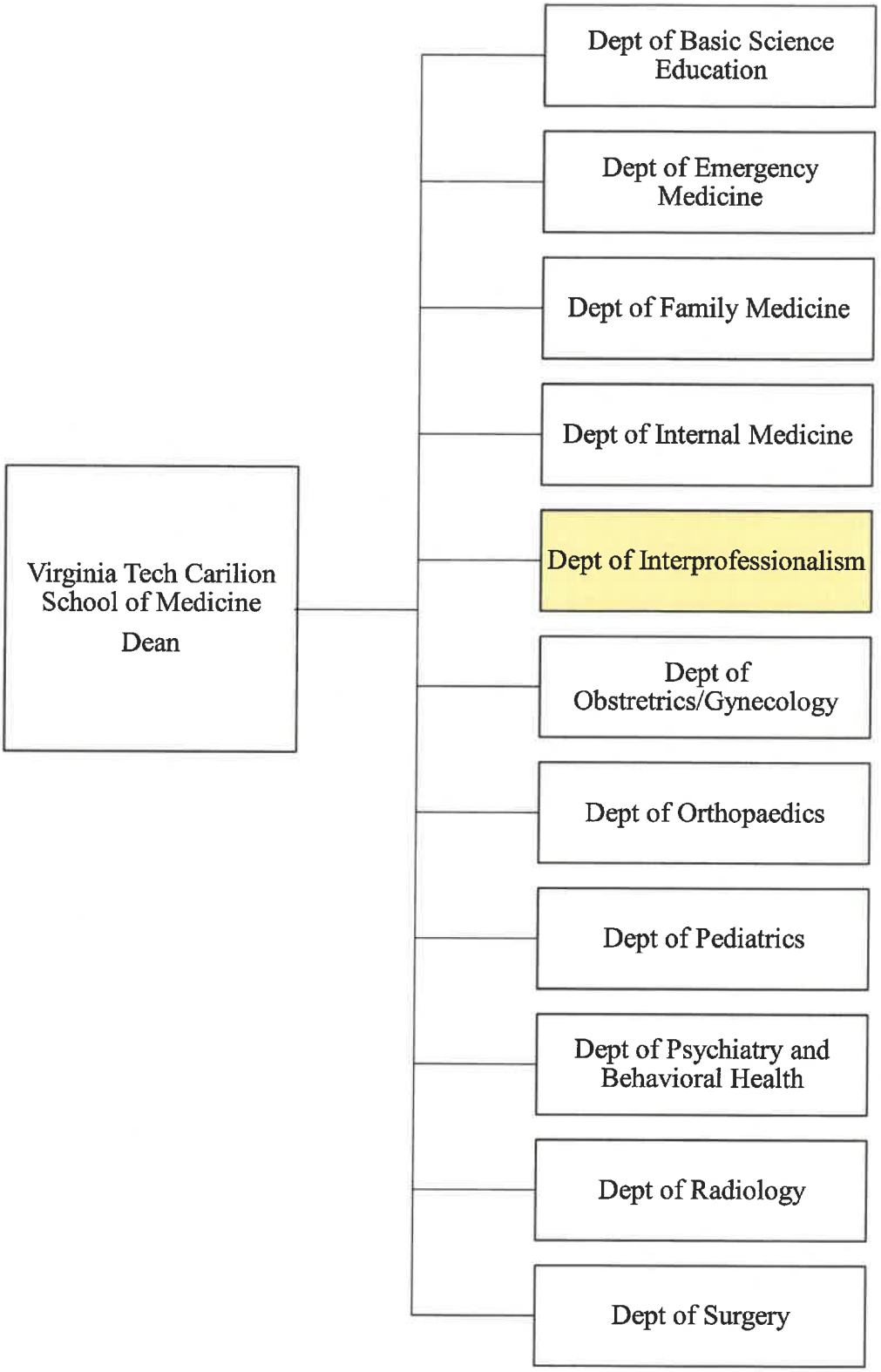
Appendix C presents the organizational structure of the School after the department name change.

Appendices

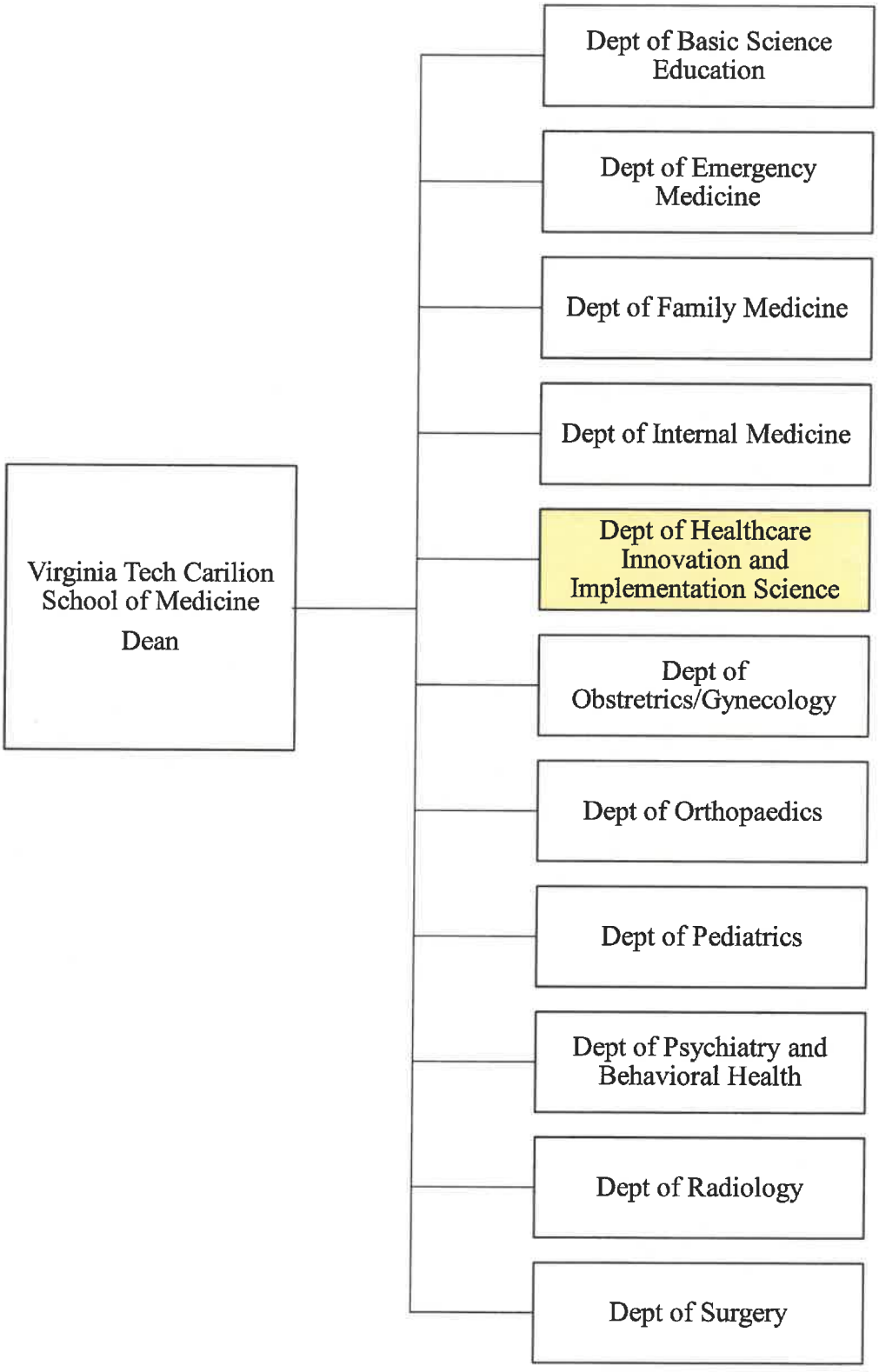
Appendix A
List of Medical Schools

Institution	Department/Unit	Website
Pennsylvania State University, College of Medicine	Department of Health Systems Science	https://med.psu.edu/health-systems-science
Kaiser Permanente, School of Medicine	Department of Health Systems Science	https://medschool.kp.org/about/offices-and-departments/department-of-health-systems-science
Mayo Clinic, College of Medicine and Science	College of Medicine and Science	https://college.mayo.edu/academics/health-sciences-education/
University of Houston, College of Medicine	Department of Health Systems and Population Sciences	https://www.uh.edu/medicine/education/departments/health-systems-population-health-sciences/
University of Massachusetts, School of Medicine	School of Medicine	https://www.umassmed.edu/oume/curriculum/health-systems-science/
University of Michigan, Medical School	Department of Learning Health Sciences	https://medicine.umich.edu/dept/learning-health-sciences
Wake Forest University, School of Medicine	Department of Implementation Science	https://school.wakehealth.edu/Departments/Implementation-Science

Appendix B
Current Organizational Structure



Appendix C
Proposed Organizational Structure



Attachment 1
Article of Support

Health Systems Science in Medical Education: Unifying the Components to Catalyze Transformation

Jed D. Gonzalo, MD, MSc, Anna Chang, MD, Michael Dekhtyar, MEd, Stephanie R. Starr, MD, Eric Holmboe, MD, and Daniel R. Wolpaw, MD

Abstract

Medical education exists in the service of patients and communities and must continually calibrate its focus to ensure the achievement of these goals. To close gaps in U.S. health outcomes, medical education is steadily evolving to better prepare providers with the knowledge and skills to lead patient- and systems-level improvements. Systems-related competencies, including high-value care, quality improvement, population health, informatics, and systems thinking, are needed to achieve this but are often curricular islands in medical education, dependent on local context, and have lacked a unifying framework. The third pillar of medical education—health systems science (HSS)—complements the basic and clinical sciences and integrates the full range of systems-related competencies. Despite the movement toward HSS, there remains uncertainty and significant inconsistency in the application of HSS concepts and nomenclature within health care and medical education. In this Article, the authors (1) explore the historical context of several key systems-related competency areas; (2) describe HSS and highlight a schema crosswalk between HSS and systems-related national competency recommendations, accreditation standards, national and local curricula, educator recommendations, and textbooks; and (3) articulate 6 rationales for the use and integration of a broad HSS framework within medical education. These rationales include: (1) ensuring core competencies are not marginalized, (2) accounting for related and integrated competencies in curricular design, (3) providing the foundation for comprehensive assessments and evaluations, (4) providing a clear learning pathway for the undergraduate–graduate–workforce continuum, (5) facilitating a shift toward a national standard, and (6) catalyzing a new professional identity as systems citizens. Continued movement toward a cohesive framework will better align the clinical and educational missions by cultivating the next generation of systems-minded health care professionals.

The evolution of the U.S. health care system and misalignment between desired outcomes, costs, and experience of care have stimulated a paradigm shift in health professions education.[1] This shift includes training that allows for learners to practice and lead in an evolving, complex health care landscape, with the goal of ensuring patients and populations receive high-quality care. Several medical education and health system leaders have recommended educational and clinical outcomes be coproduced with patients, health care professionals, health systems, and communities, and above all else, be "centered around the patient."[2,3]

For medical education, the reexamination and reenvisioning of an expanding set of systems-related competencies require significant shifts in the process, content, and assessment of learning.[4–6] Many of these competencies are not new, but educators struggle to operationalize them across the continuum from undergraduate medical education (UME) to graduate medical education (GME) to the professional workforce—for example, the Accreditation Council for Graduate Medical Education (ACGME) systems-based practice (SBP) competency.[7,8] The ACGME's Clinical Learning Environment Review Pathways to Excellence initiative has identified gaps in the health system's ability to facilitate resident education in multiple SBP-related areas, including patient safety (PS), quality improvement (QI), and care transitions.[9,10] Additionally, systems-related competencies, including high-value care, QI, population health, informatics, and systems thinking, are often relegated to isolated pockets in educational programs depending on local context, including curricular priorities and available expertise.[11–13] Such treatment of these competencies contributes to disjointed learning, potentially compromising clinical practice and professional development.[4,14] Despite many recommendations to better prepare learners to lead in evolving health systems, an inertia for such change has limited significant transformation.[1,15,16]

The third pillar of medical education, health systems science (HSS), provides a comprehensive framework to accelerate this change and integrate the full range of systems-related competencies.[6] HSS is necessary to ensure the basic and clinical sciences reach their full potential in terms of impacting patient health and achieving the Quadruple Aim.[17,18] The HSS framework cohesively unites previously scattered systems-related competencies and is now being used by dozens of medical school and residency programs and is informing national initiatives.[6,19–21] Despite this movement, there remain uncertainty and significant inconsistency in the application of HSS concepts and nomenclature within health care and medical education. For example, some still equate HSS with specific content areas (e.g., QI).[14] These understandable

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

Correspondence should be addressed to Jed D. Gonzalo, Division of General Internal Medicine, Penn State Health Milton S. Hershey Medical Center, HO34, 500 University Dr., Hershey, PA 17033; telephone: (717) 531-8161; email: jgonzalo@pennstatehealth.psu.edu; Twitter: @Jed_Gonzalo15.

Acad Med. 2020;95:1362–1372.
First published online April 13, 2020
doi: 10.1097/ACM.0000000000003400

Supplemental digital content for this article is available at http://links.lww.com/ACADMED/A906.

tensions occur within educational settings in which faculty and learners have numerous competing priorities, creating challenges for the integration of new HSS content.[8,22–25] These struggles highlight the need for a unified framework, which can be clarified by examining the historical context in which systems-related learning has occurred and the similarities and differences between HSS and related content.[26]

In this Article, we (1) explore the historical context of several key systems-related competency areas; (2) describe HSS and highlight a schema crosswalk between HSS and systems-related national competency recommendations, accreditation standards, national and local curricula, educator recommendations, and textbooks; and (3) articulate 6 rationales for the use and integration of a broad HSS framework within medical education. Our primary goal is to provide the rationale and guidance for unifying related yet distinctly different systems-related components into the HSS framework to catalyze medical education, as well as health care delivery, transformation. We pursued this work because we believe the lack of a shared mental model is hampering medical education and health care reform.

History, Landscape, and Rationale for HSS

To understand the unique nature of and need for an HSS framework, we begin with the history of several key systems-related competencies. The topics in the following sections are included within HSS, but not all HSS topics are reviewed here. While each individual competency area is critical for the transformation of medical education, focusing solely on any one area (e.g., high-value care) marginalizes other critical HSS competencies, which are necessary for a larger professional identity as "systems citizens" (described below).[14] We propose a unified framework that spans the UME–GME–workforce continuum.

SBP

SBP, and the closely related practice-based learning and improvement, originated in the late 1990s via the ACGME Core Competency Project, which followed the Harvard Medical Practice Study's revelation of unsafe conditions in clinical care.[27–30] SBP requires residents to "demonstrate an awareness of and responsiveness to the larger context and system of health care, and the ability to effectively call on other resources in the system to provide optimal health care."[27] Several SBP-related competencies capture a broad scope of physician practice, including interprofessional collaboration, care coordination, cost-conscious care, and systems error identification.[31,32] Establishing the SBP competency was a significant step forward, but program directors have encountered challenges in operationalizing and evaluating SBP in clinical learning environments.[7,12,33] However, even with the introduction of SBP milestones, studies exploring similarities across GME programs identified few HSS-related themes (e.g., economics, health care delivery, community engagement).[12,34] These themes do not provide a comprehensive core of the systems-related competencies reflected in the larger HSS framework. Despite these gaps and challenges, SBP has created space for the systems-related learning agenda, which we believe can be better informed by HSS to ensure graduates are prepared to meet society's needs.

QI/PS

In the late 1990s, the Institute of Medicine (now the National Academy of Medicine) increased focus on QI/PS as core competencies in medical education by reporting on quality and safety events, including diagnostic and other medical errors.[29,35–38] The QI/PS agenda is reflected in one of the Association of American Medical Colleges (AAMC) 13 Core Entrustable Professional Activities (Core EPAs) for Entering Residency and is a core GME requirement.[9,39,40] Further, the Institute for Healthcare Improvement's Model for Improvement and Open School curriculum includes several HSS areas (e.g., health care processes, variation and measurement, customer knowledge, leadership, collaboration, social context).[41] With this rising awareness, local and national faculty development efforts in QI/PS are increasing. Both local (e.g., the Brody School of Medicine's Teachers for Quality Academy) and national (e.g., the Society of Hospital Medicine's Quality & Safety Educators Academy) programs help educators develop QI/PS competencies and change management skills, with the goal of application in local environments.[20,42]

Interprofessional education

The history of interprofessional education (IPE) and interprofessional collaborative care (IPCC) dates to the 1960s in Europe, with steady integration since then into U.S. medical education. With the push to minimize "professional silos," educators have developed curricula to increase learning from, with, and about colleagues from different health professions.[43–45] The Liaison Committee on Medical Education (LCME) IPE requirement, targeted funding from the Josiah Macy Jr. Foundation, and the creation of a research and practice network (National Center for Interprofessional Practice and Education) have advanced this educational agenda.[29,46,47] IPE and IPCC are applied in a variety of contexts, including QI/PS, population health, and specialty-specific areas.[48] However, IPE has been a challenge to operationalize and assess within clinical learning environments. As a result, IPE is a key focus area that integrates across multiple HSS areas and cannot stand alone. That is, the IPE competencies are mutually strengthened, enhanced, and most meaningful in the larger HSS context.[46]

Social determinants of health

Some aspects of the social determinants of health (SDH) have been part of the medical interview for decades.[49,50] For example, a primary focus of taking a patient's social history has been to identify risk factors like substance use, occupational exposures, high-risk sexual behavior, and living situation. Over the past 20 years, there has been an increasing awareness of other factors related to health outcomes (e.g., food insecurity, adverse childhood experiences, zip code).[51–53] Some data suggest the SDH have more impact on U.S. health outcomes than behavior, genetics, or health care delivery.[52] In 2007, the AAMC recommended medical schools increase SDH and behavioral health curricula.[54,55] A *New England Journal of Medicine* series entitled "Case Studies in Social Medicine" promises to make an important contribution to this HSS area, using patient cases to explore how social structures affect health, with the authors of one of the studies in this series arguing for increased educational focus on social factors to improve patient outcomes.[56]

Population health

Related to the SDH, there is increasing literature focused on public, population,

and global health.[57,58] Many UME programs focus explicitly on addressing community needs, and both UME and GME programs have worked to advance learner competence in population health.[59] Global health programs are popular in UME, with nearly 40% of U.S. medical schools sponsoring opportunities for foreign travel.[60] While these areas are important, they are strengthened by the more comprehensive and interrelated framework of HSS. Engaging with the SDH; public, population, and global health; cultural humility; structural biases; and stereotypes while also considering health care delivery, policy, economics, and informatics provides a meaningful context for applying systems thinking and improving outcomes.

High-value care

In response to increasing health care costs, medical education has increasingly emphasized the "value" of care over the past decade. Studies have shown the impact of health care utilization practices and related faculty behaviors on trainees, with the effects persisting for decades into practice.[61–64] Value competencies were published in 2015 for use across the professional life span of physicians, nurses, pharmacists, and dentists.[65] The AAMC Core EPAs (i.e., entrustable professional activity 3) include the ability to be cost-effective when choosing diagnostic tests and treatment interventions.[66] ACGME Common Program Requirements expect all graduates to incorporate cost awareness and risk–benefit analysis into patient and/or population-based care.[67] Additionally, the American College of Physicians and the Alliance for Academic Internal Medicine defined 5 steps in teaching high-value care, which highlight evidence-based medicine, "safely doing less" conversations with patients, and shared decision making.[68] National initiatives (e.g., the Lown Institute's Right Care Series, High Value Practice Academic Alliance, Costs of Care) have advanced learning in high-value care.[69–72] Learners across the educational continuum must integrate evidence-based medicine with patient and team conversations and recognize macrosystem forces and ethical considerations as they provide high-value care in changing clinical environments. To do this well, learners will need competence in several HSS areas.

HSS: The Third Pillar of Medical Education

The HSS framework encompasses 12 distinct competency areas and is unified and interrelated in the same manner as the basic and clinical sciences (Chart 1). Although each systems-related area is a critical learning area for UME, GME, and professional workforce development, we argue that applying each independently will not result in a cohesive educational program or ideal educational outcomes. Learners require a comprehensive framework on which to "hang," integrate, and apply concepts. The systems-related areas require clear articulation, a shared mental model (ideally using a systems-thinking lens), and application via effective collaboration with diverse health professionals in clinical practice.[73,74] Just as the basic sciences include more than immunology or molecular biology, HSS encompasses multiple concepts and perspectives into a larger, more cohesive whole. A trainee can be taught the basic and clinical science to accurately diagnose and treat myocardial infarction. But how should the approach be operationalized if the patient is an immigrant with different traditional health beliefs (patient experience and context), does not have a home (SDH), and represents a population of patients with similar health gaps occurring within a community (population and community health)? How does a trainee ensure each patient's needs are addressed at each transition across the care continuum (health care delivery)? How can trainees learn to see and navigate health care systems and effectively identify levers they can influence or change (via QI/PS, advocacy, policy) to improve health? While the traditional 2-pillar model of medical education has served health care well in the Flexnerian era, new understandings of health and disease require the addition of a third pillar—HSS.[4,5,17,73,75] Educational programs should ensure basic science, clinical science, and HSS learning are optimally integrated, ideally conceptualized by learners, and operationalized using the HSS framework.

Schema Crosswalk

We developed and performed a schema crosswalk to elucidate the similarities, differences, and gaps in commonly used systems-based frameworks from a representative sample of national competency recommendations and accreditation standards (Chart 2) and national and local curricula, educator recommendations, and textbooks (Chart 3). Our data analysis methods are described in Supplemental Digital Appendix 1 (at http://links.lww.com/ACADMED/A906). We performed this crosswalk to systematically articulate gaps and similar and overlapping elements between the multiple systems-based frameworks and HSS.[12,76] We believed this analysis would highlight the significant and nuanced differences between HSS and other systems-based frameworks.[12,76] While notably most examples demonstrate limited overlap with HSS, the most commonly represented areas include teamwork, quality (including PS, effectiveness, efficiency, timeliness, patient-centered care, and equitable care), QI principles, and SDH. Although several of the examples closely capture the breadth of HSS, they generally only focus on certain HSS subdomains or address an HSS area superficially (e.g., one item on the AAMC Graduation Questionnaire [GQ]). Similar crosswalk processes can be used by educators to identify strengths or gaps in curricula. Collectively, this crosswalk includes all critical systems-related competency "puzzle pieces," which can facilitate the translation of conceptual goals into education design, program evaluation, and clinical practice.

A Call for a Unified Framework in Medical Education

We believe a more comprehensive, unified framework is needed to effectively align the medical education continuum with the Quadruple Aim (i.e., to better align the clinical and educational missions by cultivating the next generation of systems-minded health care professionals) and that there is now opportunity and momentum for operationalizing this vision. We believe HSS is ideal for facilitating this alignment, though we recognize it will require iterative improvements. Following are 6 rationales that support and justify the use of HSS as a unified framework for medical education.[26]

Rationale 1: A unified framework ensures core competencies are not marginalized

A comprehensive framework makes all of the desired knowledge, attitudes, and skills transparent for programs, evaluators,

Chart 1

Frameworks of the 3 Curricular Pillars—Basic, Clinical, and Health Systems Sciences—of Medical Education

Selected basic sciences[a]	Selected clinical sciences[a]	Health systems sciences[b]
Anatomy and embryology	Communication	Patient experience and context
Biochemistry and molecular biology	History taking	• Patient experience and values
Biology of cells	Physical examination	• Patient behaviors and motivations
Biology of tissue response to disease	Clinical and diagnostic reasoning and diagnosis	Health care delivery
Histology	Evidence-based medicine and biostatistics	• Structures of delivery
Human development and genetics	Behavioral health	• Processes of delivery
Immunology	Clinical medicine areas	Health care policy and economics
Microbial biology	• Adult ambulatory medicine	• Policy
Pathology	• Clinical neurology	• Economics and payment
Pathophysiology	• Emergency medicine	Population health, public health, and social determinants of health
Pharmacology	• Family medicine	• Social determinants of health
Physiology	• Internal medicine	• Public health
	• Obstetrics and gynecology	• Population health and improvement
	• Pediatrics	Clinical informatics and health technology
	• Psychiatry	• Informatics and data analytics
	• Surgery	• Decision support and evidence-based medicine
		• Technology and tools
		Value in health care
		• Quality principles and dimensions
		• Cost and waste
		• Evaluation and metrics
		Health system improvement
		• Improvement principles, processes, and tools
		• Data and measurement
		• Innovation and scholarship
		Systems thinking
		Change agency, change management, and advocacy
		Ethics and legal
		Leadership
		Teaming and teamwork

[a]Framework derived, in part, from the Liaison Committee on Medical Education Standards and the United States Medical Licensing Examination physician tasks and competencies.[99,109]
[b]Framework derived, in part, from several prior publications.[4,5,21,75,110]

and learners. A program focusing on a subset of HSS competencies without clear integration with the larger learning agenda runs the risk of marginalizing competencies, omitting learning required for professional development, or missing important connections to competencies addressed elsewhere in the curriculum. In such a program, any necessary competencies that are not clearly labeled or integrated may be overlooked or de-emphasized. Engle created the biopsychosocial model years ago because patients require more than an accounting of their pathophysiology and biomedical management.[77] What is new in the HSS framework, however, is a progressive understanding of the breadth and depth of the systems factors, collaboration, and systems-thinking skills essential to improving health for patients and communities. Effectively improving glycemic control for a patient population (e.g., all clinic patients with a hemoglobin A1C > 9.0%) includes core principles of population health, SDH, care delivery, informatics, change management, systems thinking, and QI. If medical education is going to make real progress in closing gaps in health outcomes, individual systems areas (e.g., QI/PS, value) must be explicitly integrated as part of the larger HSS framework rather than presented as separate fields.[14] Learners need both a foundational definition of health care quality (care that is safe, timely, effective, efficient, equitable, and patient centered) and a broader framework to see the relationships with concepts not traditionally included in QI/PS curricula (e.g., health equity, SDH, population health) and the relationship between value and cost.[36,78] The new Kaiser Permanente School of Medicine (in Pasadena, California) is an example that demonstrates how broad-based organizational structures are shifting toward HSS. This new medical school

Chart 2

Schema Crosswalk[a] of Health Systems Science (HSS) Learning Areas With Systems-Related National Competency Recommendations and Accreditation Standards

Representative examples	HSS domains and subdomains																						
	PEC		HCD		PE		CIHT			PPH			HVC			HSI			ST	CMA	EL	L	TW
	Pe	B	S	P	Po	EP	I	DS	T	SDH	Pu	PHI	Q	C	E	QI	D	IS					
UME competency recommendations and accreditation standards																							
AAMC Core EPAs for Entering Residency[66]	•		•	••			•		•	•			•	•		••							••
Competency domains for health professions[111]	•		•	•			•		•	•		•	•	•		•		•		•	•	•	••
Interprofessional education/collaborative care competencies[48]	•		•	••						•		•	•								•	•	••
IHI knowledge domains for improvement[112]		•	•	•						•							•	•	•			•	•
AAMC QI/PS competencies[96]		•	•				•			••		••	••	••		••	••				•		••
AAMC GQ (1998–2004)[b,c]	•	•	•	•		•		•	•	••	•	•	•	•						•	•		•
AAMC GQ (2005–2009)[b,c]	•	•	•	•	•	•	•	•	•	••	•	•	•	•		•				•	•		•
AAMC GQ (2010–2017)[b,c]	•	•	•	•	•	•	•	•	•	••	•	•	•	•		•				•		•	••
LCME Data Collection Instrument[109]	•	••			•	•	•			••		•	•								•		••
USMLE physician tasks and competencies[99]					•	•							•			•			•		•		
USMLE content outline[113]			•	•	•	•	•			•	•	•	••	•		••			•			•	••
GME competency recommendations and accreditation standards																							
ACGME SBP competency domain[27,114]			••	••								•	••	•		•				•			••
ACGME SBP, ICS, PBLI, and PRO milestones[33]	••		•	•	•	•			•	••		•	•			••		•	•	••	•	•	••
ACGME Common Program Requirements[67]		••		••								••	••			••							••
ACGME CLER Pathways to Excellence[9]			•	••						•		•	••			••	•						•

Abbreviations: AAMC, Association of American Medical Colleges; ACGME, Accreditation Council for Graduate Medical Education; CIHT, clinical informatics and health technology (I, informatics; DS, decision support; T, technology); CLER, Clinical Learning Environment Review; CMA, change management and advocacy; EL, ethics and legal; EPAs, entrustable professional activities; GME, graduate medical education; GQ, Graduation Questionnaire; HCD, health care delivery (S, structure; P, process); HSI, health system improvement (QI, quality improvement principles; D, data and measurement; IS, innovation and scholarship); HVC, high-value care (Q, quality [including patient safety, effectiveness, efficiency, timeliness, patient-centered care, and equitable care]; C, cost and waste; E, evaluation and metrics); ICS, interpersonal and communication skills; IHI, Institute for Healthcare Improvement; L, leadership; LCME, Liaison Committee on Medical Education; PBLI, practice-based learning and improvement; PE, policy and economics (Po, policy; EP, economics and payment); PEC, patient experience and context (Pe, patient experience; B, behaviors and motivation); PPH, population, public, and social determinants of health (SDH, social determinants of health; Pu, public health; PHI, population health and improvement); PRO, professionalism; QI/PS, quality improvement and patient safety; SBP, systems-based practice; ST, systems thinking; TW, teamwork, teaming, and collaboration; UME, undergraduate medical education; USMLE, United States Medical Licensing Examination.

[a]Supplemental Digital Appendix 1 (at http://links.lww.com/ACADMED/A906) describes methods used in performing the schema crosswalk; the • and •• designations were determined by investigators and represent degree of focus dedicated to an HSS area (i.e., • = minor focus, •• = moderate or high focus).

[b]*Source:* Association of American Medical Colleges Data Warehouse Codebooks, Graduation Questionnaire. Used with special permission.

[c]Questions on the AAMC GQ only included items related to perceived preparedness for residency or to the time devoted to topics in curricula (and excluded binary items related to whether a concept or item was "used" in their experience).

Chart 3

Schema Crosswalk[a] of Health Systems Science (HSS) Learning Areas With Systems-Related National and Local Curricula, Educator Recommendations, and Textbooks

Representative examples	HSS domains and subdomains																						
	PEC		HCD		PE		CIHT			PPH			HVC			HSI			ST	CMA	EL	L	TW
	Pe	B	S	P	Po	EP	I	DS	T	SDH	Pu	PHI	Q	C	E	QI	D	IS					
National and local curricula																							
IHI Open School curriculum[115]	••		•	•					•	••	•	•	••	••	•	••	••	••	•	••	•	••	••
ACP High Value Care Curriculum[116]	•					•							••	••	••	••		•					
Quality & Safety Educators Academy[42]				•									••			••	•			•			•
Harvard Medical School social medicine course[60]		•			•	•				••	••									•			•
Teachers of Quality Academy[117]			•							•	•	•	••	•		••	•			•		•	••
Mayo Clinic Alix SOM Science of HCD curriculum[21,110,118]	••	••	•	•	••	••	•	•	•	•		••	••	••	••	•	•		•	•		••	••
Educator recommendations																							
UME health policy curricula[119,120]			•	•	••	••			•	•	•	•	•		•	•					•		
Clinical Prevention and Population Health Curriculum Framework[121]		•	•	•	••	•		•	•	••	••	••	•	•						•	•		•
Population health curricular framework[122]			•	•	•	•	•		•	•	•	••					•				•	•	•
UME-21 initiative[123]			•	•			•	•		•	•		•	•									•
Textbooks																							
Population Health: Creating a Culture of Wellness[124]	•	••	•	••	•	•		••	•	••	••	••	•			•				•	•		
Understanding Patient Safety[125]		•	•	••		•	••	•	•	•			••		•	••	•		•		•		•
Understanding Value-Based Healthcare[69]		•		•	•	••			•			•	••	••		•			•	•	•	•	•
Health Systems Science and *Health Systems Science Review*[5,126]	•	•	••	••	••	••	••	••	••	••	••	••	••	••	•	••	••	•	••	•	•	••	••

Abbreviations: ACP, American College of Physicians; CIHT, clinical informatics and health technology (I, informatics; DS, decision support; T, technology); CMA, change management and advocacy; EL, ethics and legal; HCD, health care delivery (S, structure; P, process); HSI, health system improvement (QI, quality improvement principles; D, data and measurement; IS, innovation and scholarship); HVC, high-value care (Q, quality [including patient safety, effectiveness, efficiency, timeliness, patient-centered care, and equitable care]; C, cost and waste; E, evaluation and metrics); IHI, Institute for Healthcare Improvement; L, leadership; PE, policy and economics (Po, policy; EP, economics and payment); PEC, patient experience and context (Pe, patient experience; B, behaviors and motivation); PPH, population, public, and social determinants of health (SDH, social determinants of health; Pu, public health; PHI, population health and improvement); SOM, School of Medicine; ST, systems thinking; TW, teamwork, teaming, and collaboration; UME, undergraduate medical education.

[a]Supplemental Digital Appendix 1 (at http://links.lww.com/ACADMED/A906) describes methods used in performing the schema crosswalk; the • and •• designations were determined by investigators and represent degree of focus dedicated to an HSS area (i.e., • = minor focus, •• = moderate or high focus).

has 3 main departments: foundational science, clinical science, and HSS.[79,80] This forward-thinking organizational structure represents an important validation of HSS as an equal partner in medical education and patient care.[81]

While HSS captures the breadth of systems learning, a clear HSS framework with articulated milestones is critical for designing educational programs and evaluation methods but does not yet exist.[45] In addition to integrated HSS competencies, there is also the need for best learning and assessment strategies for basic science, clinical science, and HSS across the life span of the educational continuum.[8] More work is needed to advance the use of HSS as a comprehensive framework.

Rationale 2: A unified framework accounts for related and integrated competencies in curricular design

Curriculum designers need a comprehensive framework to develop optimal strategies for learning. Educators would ideally have a firm understanding of conceptual building blocks (e.g., value as a combination of quality and cost), an evidence-informed approach to curricular design that ensures the optimal developmental sequence of concepts, a spiral approach to applying concepts across disciplines, coursework (on the basic and clinical sciences and humanities), and clinical contexts aligned with Bloom's taxonomy.[82] For example, population health may be most optimally integrated into the curriculum after a systematic sequence of learning in health care delivery, SDH, systems thinking, and informatics. Learners' exploration of critical issues related to population factors requires this larger framework and the common nomenclature gained from already having knowledge of these other areas.[83]

Some UME curricula include short immersion courses focused on leadership, IPE, or patient handoffs between care settings. These courses often have different directors, and their learning goals may not align with an existing core competency map that facilitates connections across HSS competencies. As a result of this and similar missed connections, there may be unintentional redundancy and deficiencies in HSS curricula. With the emergence of dean- and director-level HSS positions along with national initiatives and grant programs by the American Medical Association (AMA), ACGME, and Kern Institute, UME and GME programs are developing the infrastructure to integrate all HSS competencies across the educational continuum.[84–86]

Rationale 3: A unified framework provides the foundation for comprehensive assessments and evaluations

The goal of synthesizing basic science, clinical science, and HSS competencies is difficult to achieve if curricular development and assessment occur in silos and include basic science, clinical science, and an amalgam of other curricular topics. With little consensus on how to best integrate new education frameworks along the continuum of medical education, educators and learners need a unified nomenclature that more aptly fits current education and health care systems.[87] If orphan curricular areas remain fragmented, assessments and evaluations may not align with the core competencies of the larger HSS framework.

For example, when the Penn State College of Medicine created a student patient navigator program for first-year medical students (linking students with interprofessional clinicians in diverse clinical settings to contribute to improving patient outcomes), the program required a systematic evaluation and assessment plan that reflected student learning and program goals.[88–90] Expectations for student contributions were broad, including collaborating with other health care professionals to identify barriers to care (e.g., health care structures and processes, SDH, IPCC) and understanding and navigating health systems issues (e.g., population health, policy, economics).[91] Bringing these related areas together in a comprehensive HSS framework created the opportunity to collaborate with other educators on a meaningful approach to assessment and evaluation.[92] Similar education efforts will require a common understanding of HSS and adoption of a common language.

Rationale 4: A unified framework provides a clear learning pathway for the UME–GME–workforce continuum

Learner progression from classroom to clinical settings, from medical school to residency, and from residency to the physician workforce can be enhanced with a comprehensive framework of competencies.[8,93] Educational handoffs at critical training transitions lack standardized competencies and expectations, and there are differing priorities for these handoffs across UME stakeholders, GME stakeholders, and accrediting bodies.[75,94] The LCME Standards and Data Collection Instrument (DCI, with supporting data from the AAMC GQ) are not fully aligned with the AAMC Core EPAs or ACGME SBP milestones, potentiating gaps in these transitions. For example, a graduating student may leave medical school with a solid background in population health, only to enter a residency program that focuses solely on QI/PS. The lack of widespread HSS framework use throughout the UME–GME–workforce continuum creates additional learner vulnerabilities during high-stress transitions and threatens optimal professional development.

It is considered unacceptable for a medical school to graduate a student who cannot care for patients with acute myocardial infarctions, but it is acceptable to graduate a student who cannot care for patients with acute abdomens. Why, in the context of 21st-century health care, is it acceptable for a student to know about QI/PS but not about health informatics, population health, or value? Why is it acceptable for a student to perform clinical reasoning well but not systems thinking? While distinct UME–GME and GME–workforce transitions will likely remain within medical education, medical education can adopt a comprehensive HSS framework that informs educational programs at all levels, ensuring a common language for improving educational transitions.

Rationale 5: A unified framework facilitates a shift toward a national standard

The HSS framework provides the foundation for future work on core and elective systems-related competencies in medical education.[95] A clearly articulated set of goals across all HSS areas will allow programs to integrate the most highly prioritized competencies in an effective, developmental sequence and allocate appropriate time and curricular

space.[8,23] Current UME frameworks for systems-related competencies include the AAMC Core EPAs (which address care transitions and PS), AAMC QI/PS competencies (which address quality, data transparency, and measurement), and locally developed competency maps.[96] This lack of a comprehensive UME framework limits larger-scale prioritization of what should be expected of graduating learners from U.S. medical schools. With a nationally agreed-on HSS framework and integration into expectations for educational programs, educators can begin to standardize expectations for UME and facilitate the necessary cultural shift for addressing mixed student receptivity to HSS.[13,24] Additionally, a unifying HSS framework can help each specialty (e.g., pediatrics, addiction medicine, surgery) develop aspirational milestones unique to their trainees. Accrediting organizations (e.g., LCME), supportive organizations (e.g., AAMC), and licensing boards (e.g., National Board of Medical Examiners [NBME]) can accelerate or hinder the development of national standards. About a decade ago, the AAMC GQ included several systems-related items focused on economics, health care systems, managed care, and care delivery.[97] In 2011, these items were replaced with one item: "I have a fundamental understanding of the issues in social sciences of medicine (e.g., ethics, humanism, professionalism, organization and structure of the health care system)."[98] Then, in 2019, this item was supplemented with 3 HSS items (see Supplemental Digital Appendix 2 at http://links.lww.com/ACADMED/A906).[98] Additionally, the required LCME DCI has limited sections focused on HSS and only ~6% of the content in the United States Medical Licensing Examination (USMLE) outline is HSS-related.[99] In 2019, the NBME and AMA codeveloped a new HSS subject examination for UME.[100] Further modifications to the DCI, GQ, and USMLE to include additional HSS content could accelerate formal integration of HSS into the mainstream of medical education. Lastly, professional workforce development may benefit from the HSS framework as it could articulate critical learning areas for physicians and other health professionals to simultaneously transform health care delivery and the education of trainees within clinical learning environments.[20,92]

Rationale 6: A unified framework catalyzes a new professional identity as "systems citizens"

HSS provides a core framework for technical skill development for physicians (and potentially other health professionals such as nurses, therapists, and pharmacists). HSS also catalyzes an equally important shift toward a new "systems citizens" professional identity that extends beyond physicians' characteristics and traits (e.g., altruism, trustworthiness, compassion, respect for others).[101–104] A concept first established by Senge in relation to societies, situated by Hafferty in the context of health care, and applied by several of our works, systems citizens are health care professionals who are in a symbiotic relationship with the health care system (not operating within an isolated microenvironment focused on the biomedical sciences).[3,13,101,105–107] Systems citizenship requires physicians to be stewards, ambassadors, and trustees, ensuring collaborative relationships within and between systems to achieve ideal patient outcomes.[105] Educators' goals should not be to develop physicians with biomedical acumen who possess inconsistent working knowledge and interest in HSS. Educators should be aiming for a professional identity that promotes physicians as citizens of a health care "country," where they share with patients and communities the responsibility of and coproduce health care delivery transformation.[3,108] HSS includes the core competencies that systems citizens require and provides the shared language for this evolving professional identity.[83]

Conclusions

Dispersed systems-related competencies have variably been a part of U.S. medical education for several decades. Rapid advances in how the medical community understands complex determinants of health in patients and populations have fueled the need to organize and expand these competencies into a unified comprehensive framework—the HSS framework. This framework addresses important gaps in medical education and provides the nomenclature for patient-centered practice and physician leadership within medical education and health care. Accelerating the transition to HSS as a full partner with the basic and clinical sciences will, among other things, enhance alignment along the UME–GME–workforce continuum, support a standardized set of prioritized competencies, and catalyze the development of systems citizens.

Acknowledgments: The authors would like to acknowledge the clinicians, educators, system leaders, students, and other collaborators who have invested their time to contribute to the educational mission at the authors' medical schools, and David Matthew (Association of American Medical Colleges [AAMC]) for providing the AAMC Graduation Questionnaire (GQ) Data Warehouse Codebooks and his assistance with descriptions of AAMC GQ-related content in the paper.

Funding/Support: This project was performed with financial support from the Josiah Macy Jr. Foundation and the American Medical Association (AMA) as part of the Accelerating Change in Medical Education initiative.

Other disclosures: J.D. Gonzalo and S.R. Starr are coeditors of a textbook on health systems science (Elsevier, 2016), and J.D. Gonzalo is coeditor of a textbook on health systems science review (Elsevier, 2019). E.S. Holmboe is coeditor of a textbook on assessment (Elsevier, 2018) and is employed by the Accreditation Council for Graduate Medical Education.

Ethical approval: Reported as not applicable.

Disclaimers: The content of and views expressed in this paper reflect the views of the authors and do not necessarily represent the views of the AMA, Josiah Macy Jr. Foundation, or other participants in the Accelerating Change in Medical Education initiative.

Data: The AAMC GQ data from prior years were obtained in collaboration with the AAMC and analyzed with their permission. The data team from the AAMC reviewed and approved the manuscript before publication.

J.D. Gonzalo is associate professor of medicine and public health sciences and associate dean for health systems education, Penn State College of Medicine, Hershey, Pennsylvania; ORCID: https://orcid.org/0000-0003-1253-2963.

A. Chang is professor of medicine and Gold-Headed Cane Endowed Education Chair in Internal Medicine, University of California, San Francisco School of Medicine, San Francisco, California.

M. Dekhtyar is former research associate, Medical Education Outcomes, American Medical Association, Chicago, Illinois; ORCID: https://orcid.org/0000-0002-8548-3624.

S.R. Starr is associate professor of pediatrics and director of science of health care delivery education, Mayo Clinic Alix School of Medicine, Rochester, Minnesota; ORCID: https://orcid.org/0000-0001-9259-3576.

E. Holmboe is chief research, milestones development, and evaluation officer, Accreditation Council for Graduate Medical Education, Chicago, Illinois, adjunct professor of medicine, Yale University, New Haven, Connecticut, and adjunct professor, Feinberg School of Medicine, Northwestern University, Chicago, Illinois.

D.R. Wolpaw is professor of medicine and humanities, Penn State University College of Medicine, Hershey, Pennsylvania.

References

1 Committee on the Governance and Financing of Graduate Medical Education; Board on Health Care Services; Institute of Medicine; Eden J, Berwick D, Wilensky G, eds. Graduate Medical Education That Meets the Nation's Health Needs. Washington, DC: National Academies Press; 2014.
2 Wong BM, Holmboe ES. Transforming the academic faculty perspective in graduate medical education to better align educational and clinical outcomes. Acad Med. 2016;91:473–479.
3 Batalden M, Batalden P, Margolis P, et al. Coproduction of healthcare service. BMJ Qual Saf. 2016;25:509–517.
4 Gonzalo JD, Dekhtyar M, Starr SR, et al. Health systems science curricula in undergraduate medical education: Identifying and defining a potential curricular framework. Acad Med. 2017;92:123–131.
5 Skochelak SE, Hawkins RE, Lawson LE, Starr SR, Borkan J, Gonzalo JD. Health Systems Science. 1st ed. Philadelphia, PA: Elsevier; 2016.
6 Gonzalo JD, Haidet P, Papp KK, et al. Educating for the 21st-century health care system: An interdependent framework of basic, clinical, and systems sciences. Acad Med. 2017;92:35–39.
7 Accreditation Council for Graduate Medical Education. Clinical Learning Environment Review: National report of findings 2018: Executive summary. https://www.acgme.org/Portals/0/PDFs/CLER/CLER_2018_Executive_Summary_DIGITAL_081418.pdf. Accessed February 19, 2020.
8 Gonzalo JD, Caverzagie KJ, Hawkins RE, Lawson L, Wolpaw DR, Chang A. Concerns and responses for integrating health systems science into medical education. Acad Med. 2018;93:843–849.
9 Weiss KB, Bagian JP, Wagner R. CLER pathways to excellence: Expectations for an optimal clinical learning environment (executive summary). J Grad Med Educ. 2014;6:610–611.
10 Koh NJ, Wagner R, Newton RC, Casey BR, Sun H, Weiss KB; CLER Program. Detailed findings from the CLER National Report of Findings 2018. J Grad Med Educ. 2018;10(suppl 4):49–68.
11 Johnson JK, Miller SH, Horowitz SD. Systems-based practice: Improving the safety and quality of patient care by recognizing and improving the systems in which we work. https://www.ahrq.gov/downloads/pub/advances2/vol2/Advances-Johnson_90.pdf. Accessed February 19, 2020.
12 Edgar L, Roberts S, Yaghmour NA, et al. Competency crosswalk: A multispecialty review of the Accreditation Council for Graduate Medical Education milestones across four competency domains. Acad Med. 2018;93:1035–1041.
13 Gonzalo JD, Ogrinc G. Health systems science in undergraduate medical education: The "broccoli" of medical student education. Acad Med. 2019;94:1425–1432.
14 Djulbegovic B, Bennett CL, Guyatt G. A unifying framework for improving health care. J Eval Clin Pract. 2019;25:358–362.
15 Lucey CR. Medical education: Part of the problem and part of the solution. JAMA Intern Med. 2013;173:1639–1643.
16 Holmboe ES, Batalden P. Achieving the desired transformation: Thoughts on next steps for outcomes-based medical education. Acad Med. 2015;90:1215–1223.
17 Bodenheimer T, Sinsky C. From Triple to Quadruple Aim: Care of the patient requires care of the provider. Ann Fam Med. 2014;12:573–576.
18 Sklar DP, Hemmer PA, Durning SJ. Medical education and health care delivery: A call to better align goals and purposes. Acad Med. 2018;93:384–390.
19 American Medical Association. Accelerating Change in Medical Education Initiative. 2013. http://www.ama-assn.org/sub/accelerating-change/index.shtml. [No longer available.] Accessed July 1, 2014.
20 Baxley EG, Lawson L, Garrison HG, et al. The Teachers of Quality Academy: A learning community approach to preparing faculty to teach health systems science. Acad Med. 2016;91:1655–1660.
21 Starr SR, Reed DA, Essary A, et al. Science of health care delivery as a first step to advance undergraduate medical education: A multi-institutional collaboration. Healthc (Amst). 2017;5:98–104.
22 Gonzalo JD, Haidet P, Blatt B, Wolpaw DR. Exploring challenges in implementing a health systems science curriculum: A qualitative analysis of student perceptions. Med Educ. 2016;50:523–531.
23 Gonzalo JD, Baxley E, Borkan J, et al. Priority areas and potential solutions for successful integration and sustainment of health systems science in undergraduate medical education. Acad Med. 2017;92:63–69.
24 Mills LM, Hoffman AB, Khan A, Lai CJ. Integrating health systems science in early undergraduate medical education: Barriers to implementation and lessons learned. MedEdPublish. 2017;6:35.
25 Gotlib Conn L, Nathens AB, Soobiah C, Tien H, Haas B. Uncovering cultural barriers to quality improvement learning in a trauma program: An ethnographic study. J Surg Educ. 2019;76:497–505.
26 Bordage G, Harris I. Making a difference in curriculum reform and decision-making processes. Med Educ. 2011;45:87–94.
27 Accreditation Council for Graduate Medical Education. Outcomes project. 1999. http://www.acgme.org/outcome/comp/compFull.asp. [No longer available.] Accessed March 30, 2013.
28 Ogrinc G, Headrick LA, Mutha S, Coleman MT, O'Donnell J, Miles PV. A framework for teaching medical students and residents about practice-based learning and improvement, synthesized from a literature review. Acad Med. 2003;78:748–756.
29 Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. N Engl J Med. 1991;324:370–376.
30 Batalden P, Leach D, Swing S, Dreyfus H, Dreyfus S. General competencies and accreditation in graduate medical education. Health Aff (Millwood). 2002;21:103–111.
31 Graham MJ, Naqvi Z, Encandela J, Harding KJ, Chatterji M. Systems-based practice defined: Taxonomy development and role identification for competency assessment of residents. J Grad Med Educ. 2009;1:49–60.
32 Dyne PL, Strauss RW, Rinnert S. Systems-based practice: The sixth core competency. Acad Emerg Med. 2002;9:1270–1277.
33 Edgar L, Roberts S, Holmboe E. Milestones 2.0: A step forward. J Grad Med Educ. 2018;10:367–369.
34 Holmboe ES, Edgar L, Hamstra S. The milestones guidebook. Version 2016. https://www.acgme.org/Portals/0/MilestonesGuidebook.pdf. Accessed February 19, 2020.
35 Leape LL, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. N Engl J Med. 1991;324:377–384.
36 Institute of Medicine Committee on Quality of Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: National Academies Press; 2001.
37 Horak BJ, Welton W, Shortell S. Crossing the quality chasm: Implications for health services administration education. J Health Adm Educ. 2004;21:15–38.
38 Institute of Medicine. Improving diagnosis in health care: Quality chasm series. Report in Brief. http://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/2015/Improving-Diagnosis/DiagnosticError_ReportBrief.pdf. [No longer available.] Published September 2015. Accessed February 19, 2020.
39 Headrick LA, Baron RB, Pingleton SK, et al. Teaching for quality: Integrating quality improvement and patient safety across the continuum of medical education. https://www.aamc.org/system/files/c/2/494316-teachingforqualityintegratingqualityimprovementandpatientsafety.pdf. Accessed February 19, 2020.
40 Wachter RM. Understanding Patient Safety. New York, NY: McGraw-Hill Medical; 2008.
41 Institute for Healthcare Improvement. Eight knowledge domains for health professional students. http://www.ihi.org/education/IHIOpenSchool/resources/Pages/Publications/EightKnowledgeDomainsForHealthProfessionStudents.aspx. Accessed February 19, 2020.
42 Myers JS, Tess A, Glasheen JJ, et al. The Quality and Safety Educators Academy: Fulfilling an unmet need for faculty development. Am J Med Qual. 2014;29:5–12.
43 Thistlethwaite J. Interprofessional education: A review of context, learning and the research agenda. Med Educ. 2012;46:58–70.
44 Thistlethwaite J. Interprofessional education: 50 years and counting. Med Educ. 2016;50:1082–1086.
45 Frenk J, Chen L, Bhutta ZA, et al. Health professionals for a new century: Transforming education to strengthen health systems in an interdependent world. Lancet. 2010;376:1923–1958.

46 Dow A, Thibault G. Interprofessional education—A foundation for a new approach to health care. N Engl J Med. 2017;377:803–805.
47 Carney PA, Brandt B, Dekhtyar M, Holmboe ES. Advancing health professions education research by creating a network of networks. Acad Med. 2018;93:1110–1112.
48 Interprofessional Education Collaborative. Core competencies for interprofessional collaborative practice: 2016 update. https://hsc.unm.edu/ipe/resources/ipec-2016-core-competencies.pdf. Accessed February 19, 2020.
49 Bickley LS, Szilagyi PG, Bates B. Bates' Guide to Physical Examination and History Taking. 9th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007.
50 Behforouz HL, Drain PK, Rhatigan JJ. Rethinking the social history. N Engl J Med. 2014;371:1277–1279.
51 Lewis JH, Whelihan K, Navarro I, Boyle KR; SDH Card Study Implementation Team. Community health center provider ability to identify, treat and account for the social determinants of health: A card study. BMC Fam Pract. 2016;17:121.
52 Hood CM, Gennuso KP, Swain GR, Catlin BB. County health rankings: Relationships between determinant factors and health outcomes. Am J Prev Med. 2016;50:129–135.
53 Chetty R, Stepner M, Abraham S, et al. The association between income and life expectancy in the United States, 2001-2014. JAMA. 2016;315:1750–1766.
54 Association of American Medical Colleges. Behavioral and social science foundations for future physicians: Report of the Behavioral and Social Science Expert Panel. https://www.aamc.org/system/files/d/1/271020-behavioralandsocialsciencefoundationsforfuturephysicians.pdf. Published November 2011. Accessed May 15, 2020.
55 Westerhaus M, Finnegan A, Haidar M, Kleinman A, Mukherjee J, Farmer P. The necessity of social medicine in medical education. Acad Med. 2015;90:565–568.
56 Stonington SD, Holmes SM, Hansen H, et al. Case studies in social medicine—Attending to structural forces in clinical practice. N Engl J Med. 2018;379:1958–1961.
57 Maeshiro R, Johnson I, Koo D, et al. Medical education for a healthier population: Reflections on the Flexner Report from a public health perspective. Acad Med. 2010;85:211–219.
58 Institute of Medicine Committee on Behavioral and Social Sciences in Medical School Curricula; Cuff PA, Vanselow NA, eds. Improving Medical Education: Enhancing the Behavioral and Social Science Content of Medical School Curricula. Washington, DC: National Academies Press; 2004.
59 Morley CP, Rosas SR, Mishori R, et al. Essential public health competencies for medical students: Establishing a consensus in family medicine. Teach Learn Med. 2017;29:255–267.
60 Kasper J, Greene JA, Farmer PE, Jones DS. All health is global health, All medicine is social medicine: Integrating the social sciences into the preclinical curriculum. Acad Med. 2016;91:628–632.
61 Leep Hunderfund AN, Dyrbye LN, Starr SR, et al. Role modeling and regional health care intensity: U.S. medical student attitudes toward and experiences with cost-conscious care. Acad Med. 2017;92:694–702.
62 Chen C, Petterson S, Phillips R, Bazemore A, Mullan F. Spending patterns in region of residency training and subsequent expenditures for care provided by practicing physicians for Medicare beneficiaries. JAMA. 2014;312:2385–2393.
63 Sirovich BE, Lipner RS, Johnston M, Holmboe ES. The association between residency training and internists' ability to practice conservatively. JAMA Intern Med. 2014;174:1640–1648.
64 Leep Hunderfund AN, Starr SR, Dyrbye LN, et al. Imprinting on clinical rotations: Multisite survey of high- and low-value medical student behaviors and relationship with healthcare intensity. J Gen Intern Med. 2019;34:1131–1138.
65 Moriates C, Dohan D, Spetz J, Sawaya GF. Defining competencies for education in health care value: Recommendations from the University of California, San Francisco Center for Healthcare Value Training Initiative. Acad Med. 2015;90:421–424.
66 Association of American Medical Colleges. Core Entrustable Professional Activities for Entering Residency: Curriculum Developers' Guide. Washington, DC: Association of American Medical Colleges; 2014.
67 Accreditation Council for Graduate Medical Education. Common program requirements. https://www.acgme.org/What-We-Do/Accreditation/Common-Program-Requirements. Accessed February 19, 2020.
68 Smith CD; Alliance for Academic Internal Medicine–American College of Physicians High Value; Cost-Conscious Care Curriculum Development Committee. Teaching high-value, cost-conscious care to residents: The Alliance for Academic Internal Medicine–American College of Physicians Curriculum. Ann Intern Med. 2012;157:284–286.
69 Moriates C, Arora V, Shah N. Understanding Value-Based Healthcare. New York, NY: McGraw-Hill Education; 2015.
70 Moser EM, Fazio SB, Packer CD, et al. SOAP to SOAP-V: A new paradigm for teaching students high value care. Am J Med. 2017;130:1331–1336.
71 Moriates C, Shah N, Arora VM. Medical training and expensive care. Health Aff (Millwood). 2013;32:196.
72 Johnson PT, Alvin MD, Ziegelstein RC. Transitioning to a high-value health care model: Academic accountability. Acad Med. 2018;93:850–855.
73 Senge PM. The Fifth Discipline: The Art and Practice of the Learning Organization. Revised and updated ed. New York, NY: Doubleday/Currency; 2006.
74 Plack MM, Goldman EF, Scott AR, et al. Systems thinking and systems-based practice across the health professions: An inquiry into definitions, teaching practices, and assessment. Teach Learn Med. 2018;30:242–254.
75 Gonzalo JD, Ahluwalia A, Hamilton M, Wolf H, Wolpaw DR, Thompson BM. Aligning education with health care transformation: Identifying a shared mental model of "new" faculty competencies for academic faculty. Acad Med. 2018;93:256–264.
76 Caplan P. Metadata Fundamentals for All Librarians. Chicago, IL: American Library Association; 2003.
77 Engel GL. The clinical application of the biopsychosocial model. Am J Psychiatry. 1980;137:535–544.
78 Smoldt RK, Cortese DA. Pay-for-performance or pay for value? Mayo Clin Proc. 2007;82:210–213.
79 Robbins CW. Designing a new medical school for the 21st century: Kaiser Permanente School of Medicine. https://growthevidence.com/craig-w-robbins-md-mph-2. Published March 19, 2018. Accessed February 19, 2020.
80 Wilkes M, Cassel C, Klau M. If we keep doing what we're doing we'll keep getting what we're getting: A need to rethink "academic" medicine. Med Teach. 2018;40:364–371.
81 Roemer BM, Azevedo T, Blumberg B. Looking at graduate medical education through a different lens: A health care system's perspective. Acad Med. 2015;90:1231–1235.
82 Anderson LW. Bloom's Taxonomy: A Forty-Year Retrospective. Chicago, IL: NSSE; 1994.
83 Aron DC, Headrick LA. Educating physicians prepared to improve care and safety is no accident: It requires a systematic approach. Qual Saf Health Care. 2002;11:168–173.
84 MedEdNext. About. https://www.medednext.org/KNN/About.htm. Accessed February 19, 2020.
85 American Medical Association. AMA Reimagining Residency initiative. https://www.ama-assn.org/education/improve-gme/ama-reimagining-residency-initiative. Accessed February 19, 2020.
86 Accreditation Council for Graduate Medical Education. Pursuing excellence: Overview. https://www.acgme.org/What-We-Do/Initiatives/Pursuing-Excellence/Overview. Accessed February 19, 2020.
87 Holmboe ES. Competency-based medical education and the ghost of Kuhn: Reflections on the messy and meaningful work of transformation. Acad Med. 2018;93:350–353.
88 Gonzalo JD, Thompson BM, Haidet P, Mann K, Wolpaw DR. A constructive reframing of student roles and systems learning in medical education using a communities of practice lens. Acad Med. 2017;92:1687–1694.
89 Gonzalo JD, Lucey C, Wolpaw T, Chang A. Value-added clinical systems learning roles for medical students that transform education and health: A guide for building partnerships between medical schools and health systems. Acad Med. 2017;92:602–607.
90 Gonzalo JD, Dekhtyar M, Hawkins RE, Wolpaw DR. How can medical students add value? Identifying roles, barriers, and strategies to advance the value of undergraduate medical education to patient care and the health system. Acad Med. 2017;92:1294–1301.
91 Gonzalo JD, Wolpaw D, Graaf D, Thompson BM. Educating patient-centered, systems-aware physicians: A qualitative analysis of medical student perceptions of value-added clinical systems learning roles. BMC Med Educ. 2018;18:248.
92 Gonzalo JD, Chang A, Wolpaw DR. New educator roles for health systems science: Implications of new physician competencies for U.S. medical school faculty. Acad Med. 2019;94:501–506.

93 Dunham L, Dekhtyar M, Gruener G, et al. Medical student perceptions of the learning environment in medical school change as students transition to clinical training in undergraduate medical school. Teach Learn Med. 2017;29:383–391.
94 Blackmore C, Austin J, Lopushinsky SR, Donnon T. Effects of postgraduate medical education "boot camps" on clinical skills, knowledge, and confidence: A meta-analysis. J Grad Med Educ. 2014;6:643–652.
95 Gonzalo JD, Wolpaw T, Wolpaw D. Curricular transformation in health systems science: The need for global change. Acad Med. 2018;93:1431–1433.
96 Association of American Medical Colleges. Quality improvement and patient safety competencies. https://www.aamc.org/what-we-do/mission-areas/medical-education/cbme/qips. Accessed February 19, 2020.
97 Patel MS, Lypson ML, Davis MM. Medical student perceptions of education in health care systems. Acad Med. 2009;84:1301–1306.
98 Association of American Medical Colleges. 2019 AAMC Medical School Graduation Questionnaire. https://www.aamc.org/system/files/2019-08/2019gqsurvey.pdf. Accessed February 19, 2020.
99 United States Medical Licensing Examination. USMLE physician tasks/competencies. https://www.usmle.org/pdfs/tcom.pdf. Published 2019. Accessed February 19, 2020.
100 National Board of Medical Examiners. Subject exams. https://www.nbme.org/schools/subject-exams/subjects/exams.html. Accessed February 19, 2020.
101 Hafferty FW, Levinson D. Moving beyond nostalgia and motives: Towards a complexity science view of medical professionalism. Perspect Biol Med. 2008;51:599–615.
102 Cruess RL, Cruess SR. Expectations and obligations: Professionalism and medicine's social contract with society. Perspect Biol Med. 2008;51:579–598.
103 ABIM Foundation; ACP-ASIM Foundation; European Federation of Internal Medicine. Medical professionalism in the new millenium: A physician charter. J Am Coll Surg. 2003;196:115–118.
104 Kanter MH, Nguyen M, Klau MH, Spiegel NH, Ambrosini VL. What does professionalism mean to the physician? Perm J. 2013;17:87–90.
105 Senge P. Systems citizenship: The leadership mandate for this millennium. Reflections. 2006;7:1–8. https://www.conservationgateway.org/ConservationPlanning/cbd/guidance-document/key-advances/Documents/Systems%20Citizenship_The%20Leadership%20Mandate%20for%20this%20Millenium.pdf. Accessed February 19, 2020.
106 Davis CR, Gonzalo JD. How medical schools can promote community collaboration through health systems science education. AMA J Ethics. 2019;21:E239–E247.
107 Gonzalo JD, Singh MK. Building systems citizenship in health professions education: The continued call for health systems science curricula. AHRQ PSNet. https://psnet.ahrq.gov/perspective/building-systems-citizenship-health-professions-education-continued-call-health-systems. Published February 1, 2019. Accessed May 5, 2020.
108 Brennan TA. Physicians' professional responsibility to improve the quality of care. Acad Med. 2002;77:973–980.

References cited only in the charts

109 Liaison Committee on Medical Education. Standards, publications, & notification forms. http://lcme.org/publications. Accessed February 19, 2020.
110 Starr SR, Agrwal N, Bryan MJ, et al. Science of health care delivery: An innovation in undergraduate medical education to meet society's needs. Mayo Clin Proc Innov Qual Outcomes. 2017;1:117–129.
111 Englander R, Cameron T, Ballard AJ, Dodge J, Bull J, Aschenbrener CA. Toward a common taxonomy of competency domains for the health professions and competencies for physicians. Acad Med. 2013;88:1088–1094.
112 Institute for Healthcare Improvement. Knowledge domains for health professional students seeking competency in the continual improvement and innovation of health care. http://www.ihi.org/education/ihiopenschool/resources/Assets/Publications%20-%20EighthKnowledgeDomainsforHealthProfessionalStudents_5216cd8e-1867-4c77-90b6-955641ecab78/KnowledgeDomains.pdf. Published November 15, 1998. Accessed February 19, 2020.
113 United States Medical Licensing Examination. Step 1: Content outline and specifications. https://www.usmle.org/step-1. Accessed March 11, 2020.
114 Guralnick S, Ludwig S, Englander R. Domain of competence: Systems-based practice. Acad Pediatr. 2014;14(suppl 2):S70–S79.
115 Institute for Healthcare Improvement. IHI open school online courses. http://app.ihi.org/lmsspa/#/6cb1c614-884b-43ef-9abd-d90849f183d4. Accessed February 19, 2020.
116 American College of Physicians. Newly revised: Curriculum for educators and residents (version 4.0). https://www.acponline.org/clinical-information/high-value-care/medical-educators-resources/newly-revised-curriculum-for-educators-and-residents-version-40. Accessed February 19, 2020.
117 Walsh DS, Lazorick S, Lawson L, et al. The Teachers of Quality Academy: Evaluation of the effectiveness and impact of a health systems science training program. Am J Med Qual. 2019;34:36–44.
118 Havyer RD, Norby SM, Leep Hunderfund AN, et al. Science of health care delivery milestones for undergraduate medical education. BMC Med Educ. 2017;17:145.
119 Patel MS, Davis MM, Lypson ML. Advancing medical education by teaching health policy. N Engl J Med. 2011;364:695–697.
120 Patel MS, Lypson ML, Miller DD, Davis MM. A framework for evaluating student perceptions of health policy training in medical school. Acad Med. 2014;89:1375–1379.
121 Maeshiro R, Evans CH, Stanley JM, et al. Using the clinical prevention and population health curriculum framework to encourage curricular change. Am J Prev Med. 2011;40:232–244.
122 Harris D, Puskarz K, Golab C. Population health: Curriculum framework for an emerging discipline. Popul Health Manag. 2016;19:39–45.
123 Veloski JJ, Barzansky B. Evaluation of the UME-21 initiative at 18 medical schools between 1999 and 2001. Fam Med. 2004;36:S138–S145.
124 Nash DB, Fabius RJ, Skoufalos A, Clarke J, Horowitz MR. Population Health: Creating a Culture of Wellness. 2nd ed. Burlington, MA: Jones & Bartlett Learning; 2016.
125 Wachter RM, Gupta K. Understanding Patient Safety. 3rd ed. New York, NY: McGraw-Hill Education; 2018.
126 Ehrenfeld JM, Gonzalo JD. Health Systems Science Review. Philadelphia, PA: Elsevier; 2019.