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Accepted version. *Nursing Outlook*, Vol 63, No. 4 (July-August 2015): 439-445. DOI. © 2015 Elsevier. Used with permission.

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Abstract: We respond to commentaries from the American Academy of Nursing, the American Association of Colleges of Nursing, and the National Institute of Nursing Research on our thoughts about integrating emerging areas of science into nursing PhD programs. We identify areas of agreement and focus our response on cross-cutting issues arising from cautions about the unique focus of nursing science and how best to proceed with incorporation of emerging areas of science into nursing PhD programs.

Keywords: Doctoral education, Health, Nursing science, Nursing research, Research-focused doctorate

We thank the commentators from the American Association of Colleges of Nursing (Breslin, Sebastian, Trautman, & Rosseter, 2015), the American Academy of Nursing (Villarruel & Fairman, 2015), and the National Institute of Nursing Research (Grady, 2015) for their excellent discussions of our articles addressing implications of emerging and priority areas of science and their impact on preparation of the next generation of nursing scientists. Likewise, we are grateful to the anonymous peer reviewers who questioned us about some critical issues that we will address here. Our articles (Henly et al., 2015a and Henly et al., 2015b) and the commentaries focused on challenges involved in integrating advances in omics including the microbiome; behavior, behavior change, and biobehavioral science; e-science, informatics, and big data; quantitative sciences; translational science; patient-reported outcomes; and health economics into nursing PhD programs.

Together, the articles, commentaries, and reviews showed agreement about the importance of these areas to the future of nursing science as it will be driven by graduates of our PhD programs. Breslin et al. (2015) emphasized the continuing evolution of nursing PhD programs to sustain excellence and relevance; they identified education in the sciences, preparation for leadership in policy, developing a diverse community of scholars, and cross-institutional collaboration as important aspects to consider as emerging areas of knowledge are integrated into PhD programs. Villarruel & Fairman (2015) considered the social mandate for nursing research; they especially emphasized the importance of social and political context in ascribing importance to research priorities and questions. Grady (2015) discussed the intersection of emerging areas of science with the four priority areas of science identified by the NINR (symptom science, wellness, self-management of chronic conditions, and end-of-life/palliative care); she also identified technology and innovation as drivers of advances in nursing science. Cautions stemming from issues about the unique focus of nursing science and questions about how best to proceed with the incorporation of emerging areas of science into PhD programs in nursing arose in the reviews and commentaries. The major cross-cutting issues involved the domain of nursing science, the link between research and practice, methods in the emerging areas with nursing science education, and challenges in the integration of emerging areas into research-focused doctoral programs in nursing.

Here, our purpose is to respond to cross-cutting issues and discuss them briefly from our perspectives as nursing scientists and mentors to PhD students.

The Domain of Nursing Science

Biology and Nursing

The Council for the Advancement of Nursing Science Idea Festival for Nursing Science Education was grounded in the recognition that nursing science is the science of health, and the emerging areas—some of which are biology based and reliant on highly technical methods—constitute a calculated projection about future directions for nursing science (Henly et al., 2015b). One reviewer said that “these foci redirect the traditional nursing doctoral program curricula in a manner reflective of the biological underpinnings of human disease and behavior.” Our view is that exposing all PhD students to omics is essential (Conley et al., 2015). Emphasizing biological aspects of health behavior and behavior change in PhD programs offers the opportunity to fully reflect the *biopsychosocial* dimensions of health (e.g., Shaver, 1985) and nursing practice. PhD students who are not exposed to current understandings of the interaction of behavior and biological processes may be hindered in their ability to build sustainable programs of nursing research and lead multidisciplinary research teams to inform practice and positively impact the health and well-being of individuals, families, communities, and the nation.

Nursing students have long been inculcated with the biopsychosocial view from their first undergraduate courses, but despite encouragement over the years (Cowan et al., 1993, Kang, 2012 and O’Mara, 2015) and the availability of resources to support research in the biological bases of nursing (Grady, 2015), few PhD programs today include biological aspects of nursing science (Wyman & Henly, 2015). The National Research Council identifies the PhD in nursing as a biological and health science degree (Ostriker, Holland, Kuh, & Voytuk, 2011), along with fields including cell and developmental biology, genetics and genomics, pharmacology, microbiology, kinesiology, and public health. More complete development of biological aspects of nursing science will bring the field

into position for enhanced interdisciplinary collaboration with these related fields. This is critically important because it will bring the nursing lens to research that impacts health across the life span and care settings. It will also bring nursing science PhD programs into better alignment with bachelor of science in nursing and doctor of nursing practice programs, which rely on pathophysiological aspects of human biology for instruction about clinical management of health problems.

Emerging Areas and the Nature of Nursing

Nursing science as the science of health is expansive. It reflects the wide scope of nursing practice—from the health promotion and surveillance activities of public health nurses to the life support interventions of intensive care nurses—as well as the nursing systems of care that enable persons and populations to access and receive care. When considering the emerging areas, another reviewer asked for more discussion about the overlap of emerging areas with the view that nursing science is “unique in the ‘whole person’ sense,” and the reviewer was reminded of “long-standing critiques of nursing science as being overly derivative.” Nursing presence (Bunkers, 2012, pp. 12-14) and regard for persons and populations as whole and unique are claimed as hallmarks of nursing practice and nursing science (e.g., Newman, Smith, Pharris, & Jones, 2008; [also see Allen, 2014 for reconceptualization of holism to incorporate organizational relationships in to systems of care]). However, a rigid view of holism can seriously limit the development of scientific knowledge needed as the foundation for increasingly complex, person-centered nursing practice in the 21st century; efforts to consider unifying systemic, organismic, and whole-person views of holism (Kolcaba, 1997) into a more complex view (Stiles, 2011) would be beneficial.

Continued whole-person nursing research is critical, but restricting nursing research to the whole-person level creates artificial floors and ceilings that ignore real spatiotemporal scales of being—from molecules to societies, from nanoseconds to the life spans of generations—that are inherent to biological and psychosocial aspects of nursing science alike. Furthermore, the separation of biological and psychosocial perspectives may be misleading in many areas of nursing

science (e.g., symptom science; Corwin, Meek, Cook, Lowe, & Sousa, 2012). In contrast to past reductionist approaches in biology, systems biology aims at synthesizing complex biological processes as whole systems (Wanjek, 2011) and is relevant to nursing research involving questions that cut across molecular, physiological, and biobehavioral scales (Founds, 2009).

The incorporation of genomic science into nursing research addressing health behavior change, self-management of chronic illness, strategies to reduce disparities, harnessing technology to serve human needs, and enhancing end-of-life experiences have been outlined (Conley & Tinkle, 2007). At the chromosomal level, telomere length has been associated with psychosocial, environmental, and behavioral factors as well as aging (Starkweather et al., 2014). The integration of genomics with biobehavioral research has been proposed using a transplantation exemplar (Driscoll, Lyon, & McCain, 2011). Carefully designed studies that incorporate biography, social-economic factors, and omics perspectives can inform understanding of risk factors and mechanisms by which genomic variation interacts dynamically with personal experience to create disease (Krieger, 2013). Using the example of cancer nursing research, O'Mara (2015) pointed out that basic research is needed to inform care; she used preclinical work on the elucidation of mechanisms of cancer cachexia (e.g., McCarthy & Graves, 2006) to support her argument. Incorporating these dimensions of the life sciences into PhD programs will inform advances in traditional areas of nursing science (e.g., symptom science and wellness) and serve as a segue to advancing nursing as the integrated biopsychosocial discipline of health.

Technology, Design, Data, and Models

The introduction in 1981 of the IBM personal computer stands as a personal memory for many of today's leaders in nursing. It is impossible to overestimate the impact that subsequent inventions in digital technology and software have had on health, health care, and health research in the decades that followed. The revolution in personal mobile devices now supports telehealth, ambulatory monitoring, personal health monitoring, new ways to support self-management of chronic disease and to monitor population health in

real time, and wearable medical devices and robotics for real-time monitoring and intervention. None of these eventualities were imaginable at the time quality standards, and curricula were proposed and adopted for nursing PhD programs (Jamann, 1985). The current NINR (2011) strategic plan acknowledged the impact of technology on nursing science; Grady (2015) reiterated that innovation and technology constitute cross-cutting areas vital to the advancement of nursing science and health care; the American Association of Colleges of Nursing (AACN, 2010) position statement on the research doctorate included data, information, and knowledge management, processing, and analysis as key curricular elements; and we included advances in quantitative sciences including data mining methods as an emerging area with substantial relevance to nursing science (Henly et al., 2015b) and nursing science education (Henly et al., 2015a).

The advances in technology that have redefined questions about health and health interventions at all levels have simultaneously generated a revolution in methodology, with novel research designs, data collection methods, and statistical models used to make sense of data, with new and unfamiliar attributes like volume, velocity, variety, veracity, and value, available and in common use (Cios & Nguyen, n.d.). We presented the scientific context for the Idea Festival Advisory Committee (IFAC) recommendations for integrating emerging areas into PhD programs from this perspective (Henly et al., 2015b), and a reviewer was critical, saying that substantive knowledge was conflated with design and methods. However, IFAC contends that methods of data collection and analysis enabled by technology generate novel questions from which new, sometimes unanticipated, insights accrue. The substantive questions and the methods are intertwined, so instruction for advanced methods should be meshed with content and exploration of questions at the frontiers of knowledge in nursing science.

Linking Research and Practice

Nursing as a profession includes practice as well as the research that builds the science underpinning practice. Since the turn of the century, rapid and accelerating changes in health services and discoveries in health sciences have changed the landscape for nursing

practice and research. Changes in practice and research have been enabled by and embedded in new technologies that characterize new societal lifeways. Rapid advances in health sciences and health care technologies necessitate that we prepare nursing scientists who can compete for scarce research resources and continue to produce new knowledge relevant to practice. Nursing scientists with in-depth knowledge in practice–research connections are needed to ensure nursing as a discipline maintains its voice and leadership in health care delivery and policy.

We agree with Fairman and Villarruel (2015) that we need vigorous debate and continued dialogue to consider essential content for PhD scientists in the context of how they advance the practice of nursing, improve the quality of health care, shape health policy, and positively impact the health of all people in this new context. As noted by Breslin et al. (2015), expanding the knowledge base for health professional practice is increasingly reliant on interdisciplinary translational research to help close the gaps between research and practice. The IFAC endorsed translation science and patient-reported outcomes as two priority areas in research-focused doctoral education in nursing because they link practice and research, ensuring that new knowledge enters the practice setting and that practice-based knowledge informs research.

Both biological and behavioral components combine to create the “unique” individual, including health experiences over time and individual responses to nursing interventions. This awareness is moving us toward a better understanding of the individual health experience (Henly & Wyman, 2011) and precision treatment for the individual (e.g., Lessans & Dorsey, 2013) instead of our current one-size or universal approaches to promote health and well-being. Translation of research findings into real-world settings includes comparative effectiveness studies to determine which interventions work best with which populations. Similarly, person-centered nursing care embodies a rich history of findings from qualitative research to explicate the health care experiences of persons and families. These data informed the development of many quantitative self-report instruments to evaluate health status and outcomes of nursing care. Remaining is the need to validate these measures for use in practice. Now, the National Institutes of Health Patient-Reported Outcomes

Measurement Information System, reflecting health domains relevant across the broad scope of nursing science, is available for clinical and research use (Bevans, Ross, & Cella, 2014). Future nursing scientists must be prepared to conduct translational research using both objective measures of health status and health risk and, where valid, patient-reported outcomes of care.

Challenges and Practical Issues

Areas of Emphasis in PhD Programs in Nursing

The PhD is a research degree, and PhD programs are designed to prepare graduates with specialized knowledge for scholarly careers in a specific discipline; research is the sine qua non of the degree (Walker, Golde, Jones, Bueschel, & Hutchings, 2008). The research-focused doctoral program in nursing has traditionally been regarded as uniformly focused on training nursing scientists. Wider views have recently been considered; for example, a preconference session at the 2015 AACN Doctoral Education Conference highlighted models of PhD programs with various areas of emphases, such as basic science, bioethics, and health policy (AACN, 2015). Research-focused programs in nursing that provide specialization in nursing history, genomics for nursing science, and the science of nursing education are now available, and more programs are moving in these directions. As reflected in the National Research Council classification of nursing as a biological and health science (Ostriker et al, 2011), we think that science-focused PhD programs will continue as the most common "type" of program, and our recommendation is that programs clarify and announce the area(s) of scientific specialization available to PhD students (Henly et al., 2015b). The recommendation does not preclude development of other types or content emphases of PhD programs (Fairman & Villarruel, 2015), and we look forward to continued discussion of this possibility.

Core and Specialization in Emerging Areas

The very notion of "emerging" areas of science suggests new ideas, new areas of investigation, and new methods of research. It also suggests thoughtful reconsideration of requirements for training

future nursing scientists, especially delineation of what constitutes core knowledge that should be shared by all and what is best reserved for specialists. The areas we addressed (i.e., omics; health behavior, behavior change, and biobehavioral science; e-science, informatics, and big data; quantitative science; translation science; patient-reported outcomes research; and health economics) have relevance for all aspects of nursing science and at some level will become part of the core knowledge of the discipline, containing seeds for future discovery and application. This position suggests that nursing scientists will need to be conversant in these areas and that some will possess expertise in one of these areas. We recognize that it is disingenuous to suggest "adding" new program content without considering what continues to have value from the past and what can be set aside or integrated within new and emerging scientific perspectives. For reasons of practicality and efficiency, core for the 21st century cannot involve every idea, course, or class studied in the past. The rapid advance of the emerging areas and their importance to nursing science suggests urgency in resolution of questions about core and specialized knowledge.

Content and Process

Core requirements in today's nursing PhD programs resemble those of 30 years ago (Wyman & Henly, 2015). The majority of nursing PhD programs in the United States currently focus on scholarly processes, with few requirements focused on the content or essence of nursing science (Wyman & Henly, 2015). Creative approaches and curriculum models might facilitate a better balance between content and process in PhD programs. Creating a curriculum that offers core content yet allows for specialization in a particular science area is challenging in light of designing bachelor of science in nursing-to-PhD programs that can be completed in a realistic time frame and the limits set by some universities regarding the maximal number of credits in a PhD program. Additional dialogue about these issues is needed.

Scientific Workforce

Creating a pipeline (Deatrack, 2011) to ensure adequate size and optimal composition of the scientific workforce in nursing is critical

to the advancement of nursing knowledge and its application to support effective, cost-effective processes and optimal outcomes in practice. Enrollment trends in nursing PhD programs combined with anticipated retirements of current faculty are creating a shortage that is impacting education and practice (American Association of Colleges of Nursing (AACN), 2014, National Advisory Council on Nurse Education and Practice, 2010 and Smeltzer et al., 2015). The impact of the faculty shortage on nursing research is of special concern and intersects with the question of “who” can be a nursing scientist (Villarruel & Fairman, 2015). Securely integrating emerging areas of science into PhD programs will require interdisciplinary collaboration (Breslin et al., 2015 and Knafl and Grey, 2008) as well as the appointment of qualified scientists in related fields to tenure-accruing positions in schools and colleges of nursing (Henly et al., 2015a). Ensuring diversity in the scientific workforce requires ongoing institutional commitment responsive to the motivation and needs of students from underrepresented groups aspiring to become nursing scientists (e.g., Henly et al., 2006 and Kim et al., 2009).

Policy and Economics

Scientific inquiry is vital to informing health policy (Breslin et al., 2015), and economics, the science of scarcity and abundance, is an essential aspect of the information. Deliberate consideration of the policy arm of a career trajectory has been recommended (Feetham & Doering, 2015). Increased attention to the emerging areas in nursing PhD programs will prepare graduates who can be at the forefront of generating the type of evidence that will be needed to transform care and shape health policies from the organizational to the governmental levels. To fully meet the goals of individuals and organizations (including the American Academy of Nursing; www.aannet.org/strategic-plan-2014-2017), nursing scientists need a working knowledge of economics principles and methods. No policy is complete without consideration of the cost factors critical to policy decision makers. A cadre of nursing economics specialists is needed to lead efforts to systematically assess how to make choices about health and nursing policy based on cost-effectiveness, cost-benefit, cost minimization, and cost consequence analysis (Uchida-Nakakoji & Stone, in press). The theory and practice of economics is highly

mathematical, emphasizing even more the need for nursing scientists to have facility with quantitative methods.

Opportunities

This first CANS Idea Festival focused on implications of emerging and priority areas of science for nursing science education and the preparation of graduates for competitive, sustainable careers as nursing scientists. The CANS is committed to facilitating this type of national dialogue in future idea festivals. We envision that idea festivals will examine other critical questions about ideas and issues essential to the development, conduct, and use of nursing science, including career development in nursing science related to the CANS mission and strategic plan. For example, the core content in nursing PhD programs could be re-examined in light of contemporary scientific advances, innovative curricular models for nursing science education could be considered, strategies for implementing team science and interdisciplinary perspectives into research could be discussed, and ways to support nursing scientists for roles in policy advocacy could be advanced. Guidelines for submitting a new topic for an idea festival can be found on the CANS website (www.nursingscience.org).

Concluding Thoughts

Clarity about the nature of nursing as a discipline and a reasonable forecast about future directions of nursing science are essential to planning and implementing PhD programs that enable graduates to push frontiers of knowledge forward throughout their careers. We are pleased that the Idea Festival for Nursing Science Education generated so much interest and dialogue nationally from faculty, deans, policy leaders, scientific directors, and PhD students. The dialogue stimulated renewed interest and debate about nursing PhD education and how it can better prepare graduates for their future research careers. Our recommendations, focused on emerging areas of nursing science, are meant to assist nursing faculty and schools to begin their own dialogue about how to re-envision their PhD programs and curricula to prepare the next generation of nursing scientists to advance nursing science and practice for the 21st century.

Acknowledgments

Yvonne Bryan, PhD, served as the NINR Liaison for this work. Laura Smothers, MPA, Manager for the Council for the Advancement of Nursing Science, provided logistical and advisory support. The contributions of the many nursing scientists, faculty, deans and PhD directors, and students who participated in discussions as part of the CANS Idea Festival for Nursing Science Education are acknowledged with appreciation.

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Author Note. Susan J. Henly was Chair of the Council for the Advancement of Nursing Science (CANS) Idea Festival Advisory Committee. She and Donna O. McCarthy were the primary writers of the paper. Jean F. Wyman was Chair of the Steering Committee, Council for the Advancement of Nursing Science, and had significant roles in the conception and implementation of the Idea Festival for Nursing Science Education. IFAC members Jerilyn K. Allen, ScD, RN, FAAN, Johns Hopkins University School of Nursing, Baltimore, MD, and Suzanne S. Prevost, PhD, RN, COI, University of Alabama, Capstone College of Nursing, Tuscaloosa, AL, served as nonauthor contributors.

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