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Defining Core Competencies for Epidemiologists in Academic Settings to Tackle Tomorrow's Health Research Challenges: A Structured, Multi-National Effort

International Consortium on Teaching Epidemiology

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Running head: Core Competencies of Epidemiologists in Academia

Abstract

Only a few efforts have been made to define competencies for epidemiologists working in academic settings. Here we describe a multi-national effort to define competencies for epidemiologists who are increasingly facing emerging and potentially disruptive technological and societal health trends in academic research. During a 1,5 years period, we followed an iterative process that aimed to be inclusive and multi-national to reflect the various perspectives of the diverse group of epidemiologists. Competencies were developed by a consortium in a consensus-oriented process that spanned three main activities: two in-person interactive meetings in Amsterdam and Zurich and an online survey. In total, 93 meeting participants from 16 countries and 173 respondents from 19 countries contributed to the development of 31 competencies. These 31 competencies included 14 on “Developing a scientific question” and “Study planning”, 12

on “Study conduct & analysis”, 3 on “Overarching competencies” and 2 competencies on “Communication and translation”. The process described here provides a consensus-based framework for defining and adapting the field. It should initiate a continuous process of thinking about competencies and the implications for teaching epidemiology to ensure that epidemiologists working in academic settings are well prepared for today’s and tomorrow’s health research.

Keywords

Multi-national study, teaching, academic research, core competencies

Abbreviations

PhD: Doctor of Philosophy

Introduction

Defining competencies has become standard for guiding the development and assessment of educational curricula for a wide range of academic professions.(1–3) A competency is defined as the combination of knowledge, skill, and ability that professionals must have in order to perform specific functions within organizations or professional practices.(4) Defining competencies may serve different purposes such as forming curricula (e.g. master or doctoral programs), accreditation (e.g. Council on Education for Public Health in the United States) or to shape and guide a field (e.g. American College of Epidemiology). Sets of competencies are commonly developed through iterative qualitative and quantitative methods.

For Master or Doctor of Public Health graduates or public health professionals, competencies have been defined on a general level.(5–11) For example, public health

organizations like The Association of Schools of Public Health in the European Region (ASPHER) defined broad sets of competencies related to public health policy, surveillance and outbreak investigation, communication, management or capacity building.(5) To train epidemiologists for research in academia, industry or elsewhere, organizations like the American College of Epidemiology based its set of competencies mostly on the disciplines of epidemiology and biostatistics.(12) Some scholars have also suggested going beyond the classic Master or Doctor of Public Health or similar academic degrees and thinking along the full educational path from high school to graduate school to initiate the development of competencies early and in broad groups of trainees.(13,14)

Efforts have been made to define core competencies for epidemiologists specifically working in academic environments (15) and current curricula and textbooks cover basic, widely accepted concepts and special topics of epidemiology.(16–18) However, previous attempts of formulating core competencies rarely go beyond key epidemiological concepts and are not reflective of many epidemiologists' everyday experience where they are highly central, interactive and integrative members of the evidence generation process. No attempts have been made to define competencies that enable epidemiologists to be at the forefront of health research and leverage current technologies and trends such as digitalization, personalized health, participatory science, artificial intelligence, or -omics to name just a few. Moreover, an overarching framework for guiding curriculum development and prioritization of areas of competencies is missing. This is remarkable as epidemiologists in an academic setting are a driving force in producing and teaching new knowledge, promote academic

advancement and scientific inquiry in the field of health research, and therefore have a substantial impact on training and shaping not only new generations of epidemiologists but also clinical and public health scientists and health care professionals.(19,20)

Re-defining traditional epidemiological competencies to reflect the ability to lead and contribute to emerging fields in health research would be important for junior and senior epidemiologists, curriculum developers, and teachers. A general and widely accepted set of competencies is ideal to maintain relevance and robust training standards, to provide orientation for PhDs, post-doctoral researchers and senior epidemiologists and assure sustainability of the discipline. Therefore, the aim of the initiative described here was to define forward-thinking competencies that may guide the development of curricula and that provide guidance for epidemiologists who pursue a career in an academic environment.

Methods

We pursued an iterative process to develop a set of competencies for epidemiologists working in academic settings that began in June 2017 and reached a first milestone in August 2019 (Figure 1). Here, we present an overview of the key steps and present the details of the methods in the Web appendixes 1-7, Web Tables 1-2 and Web Figure 1.

The process aimed to be inclusive and multi-national from the start to reflect the various perspectives of the diverse group of epidemiologists from around the world. The process was designed to be transparent, systematic and well-documented. Generally, we aimed to develop a set of competencies that is relevant across the range from master students to senior epidemiologists in an academic setting. However, to facilitate and focus

discussions we asked participants to consider the skills and expected level of a post-doctoral researcher in epidemiology with 2 years of experience after PhD graduation.

We first composed a core group of epidemiologists from Switzerland (MP, VvW), the Netherlands (GtR) and the USA (AA, AH, AM). The core group engaged colleagues in the process, moderated discussion, and edited the results to formulate competencies. From the beginning this core group led the process and engaged a multi-national and diverse (in terms of stage of career and subfields of epidemiology) group of epidemiologists in discussion, but without actively shaping competencies. Instead, major decisions on competencies were taken by the full consortium in a consensus-oriented process and through rating exercises. To this end and in accordance with these principles, the whole process of competency definition and decision-making was spread over three main activities: two meetings in Amsterdam and Zurich as well as an online survey.

The goals of the Amsterdam meeting (January 17, 2018) were 1) to test the process of developing competencies in a structured and transparent way, 2) to generate a first set of competencies that are important for today's academic epidemiological work and 3) to consider potentially field-shifting and disruptive trends. The initial set of competencies were assigned to a study's life cycle. The Zurich meeting (June 26/27, 2018) was organized as an interactive and structured process where the initial set of competencies were discussed and revised. The focus of the meeting was then on current and future trends and how those might affect necessary competencies. Additional competencies arising from these discussions were again assigned to a study's life cycle. After the Zurich meeting, all competencies were extensively revised by the core group to produce

a clear and consistent formulation of each core competency according to established frameworks (21,22) making sure to maintain the intended meaning. We conducted two revision rounds with all participants of the Amsterdam and Zurich meetings through online collaboration. Finally, we conducted a survey between May and August 2019 to elicit, for each of the competencies, the expected competency level of a post-doctoral researcher in epidemiology in an academic setting with 2 years of experience after PhD graduation. Although not explicitly mentioned in the survey, we expected that through the survey respondents from the epidemiology community could familiarize themselves with the competencies and reflect on the impact these competencies would have on teaching epidemiology.

Results

The multi-national consortium developed 31 competencies that were organized along the four domains of a study's life cycle plus the domain of overarching competencies (see Figure 2 and Web Appendix 6 3 for details on domains and competencies). Seven competencies (A1-A3 and B1-B4) were defined for the domain of "developing a scientific question" (Web Appendix 8). They enable epidemiologists to frame relevant and clearly formulated scientific questions that address a health need and considers the existing evidence and context. "Study planning" is a critical step in health research to assure the generation of valid and meaningful evidence. The seven competencies defined for this domain fall into the categories of combining content knowledge and research methods (C1-C4) and of minimizing random error and systematic biases (D1-D3, Web Appendix 8). The domain of "study conduct & analysis" contains 12 competencies (E1-E5 and F1-F7, Web Appendix 8). This phase of a study entails numerous activities in order to

gather the required data in a timely and high-quality manner and analyze them in a sensible and reproducible way.

The two competencies (G1 and H1) in the domain of “communication and translation” enable epidemiologists to engage in science communication of their own and other’s results and bear (co-) responsibility for appropriate representation of evidence, assessment of the evidence base, and drawing correct conclusions (Web Appendix 8). Finally, the fifth domain includes three overarching competencies (O1-O3) that enable epidemiologists to act as “leaders” and facilitators between different professions, to acquire funding and complement a team when specific expertise is missing. During the development process there was ample discussion of relevant content areas (e.g. biology, immunology, genetics) and it became clear that the combination of subject and methods competence is highly important for epidemiologists working in academic settings. This is reflected in a number of explanations for competencies (see Web Appendix 4) and domain C “Combining content knowledge and research methods” (C1 to C4) explicitly refers to this important combination.

Competencies for current and future trends

The majority of competencies relate to traditional, currently important tasks for epidemiologists in academic settings. Here, we highlight a number of novel competencies that emerged from discussions about current and future trends at the Amsterdam and Zurich meetings: For example, it is increasingly common to involve stakeholders such as citizens, patients, providers, or policy makers in health research. In some instances, stakeholders have even initiated or co-led research efforts, which offers new opportunities, but also poses some challenges for health researchers.(23,24) The

consortium thus defined the core competency of being able to engage with stakeholders and the public as the ability to identify relevant health needs from their perspective (A1). Moreover, given the increasingly interdisciplinary nature of health research there is a need for researchers, who can coordinate and facilitate between research partners and/or stakeholders. Since epidemiologists may often be in an ideal position to fulfil this role, the consortium defined the competency to identify partners from various disciplines as vital to conduct health research, align partners' skills with research tasks, and act as a bridge between wide-ranging health and data disciplines (O2). A group of four competencies (B3, D3, E4, E5) relate to the set-up, critical evaluation and use of existing or new data sources that may be used to address health-related research questions. The emphasis on facility with data sources likely reflects an increasing focus on mining existing large and novel data sets including healthcare-related databases, social media and harmonized data from varied sources. C3, the competency to identify emerging technologies or methodologies in other fields for utility, highlights an awareness by participants that epidemiologists must be aware of and look outside their fields for methods, tools and expert support (O3). This is likely motivated by the adoption of novel measurement and analytic techniques emerging from a broad range of areas like engineering, computer science, biology or physics.

Results from the survey

In total, 173 persons from 19 countries completed the online questionnaire. Participants were diverse with respect to career stage and educational background. A majority (58%) of participants were women, and the median age was 44 years (interquartile range 34 to

52 years). More than half (52%) were professors, and 21% were either PhD students or postdocs. The majority of participants had a formal degree in epidemiology (62%), and almost 9 out of 10 (88%) were employed in academic settings (see Web Table 2 for details).

Table 1 shows, in descending order, the average ratings (and standard deviations) on the expected level of competency for a postdoc in epidemiology two years after PhD graduation. The analyses revealed four subjectively defined, but quite distinct core competency clusters (Figure 3). The blue cluster comprises 7 competencies that reflect key topics typically considered by introductory courses (formulating research questions, bias, confounding). Respondents indicated, with little variation (low standard deviations), that the expected level for these competencies should fall between advanced and proficient for a postdoc in epidemiology working in academic settings. By contrast, respondents consistently (low standard deviations) expected a more moderate (basic to advanced) level of competency for the three competencies within the red cluster, which pertain to assessments of the quality of databases and data handling (B3, E4) as well as the competency to adapt novel technologies (C3).

A third cluster consists of 9 competencies where there was a substantial range in expected levels of competency, and there was substantial variation in ratings among respondents. These were competencies that are often not included in current epidemiology curricula but may be relevant for epidemiological research practice (e.g. O2, identifying suitable research partners and stakeholders) or are more prevalent in sub-specialties of epidemiology (e.g. F6, qualitative and mixed research methods). A fourth cluster included 12 competencies. For these, there was moderate agreement

among respondents about the level of competency expected from a postdoc in epidemiology, but there was also variation in terms of their average rating for the expected level, ranging from an advanced level for core competency F2 to a nearly proficient level for competencies E2 and F3.

Discussion

In this multi-national effort, that included a large group of epidemiologists from around the world, we developed 31 competencies for epidemiologists working in an academic setting and organized them along a study's life cycle. We paid special attention to emerging technological and societal trends that offer novel opportunities for health research but may also disrupt some conventions of traditional health research. We used recommended wording for competencies to assure they were evaluable fits for inclusion in curricula and avoided reducing competencies to a list of important epidemiologic topics.(21,22)

The majority of competencies can be considered traditional competencies that have classically defined the field. These competencies enable the conduct of health research on questions of etiology, disease burden, diagnosis, prognosis as well as on preventive and therapeutic interventions. The importance for epidemiologists to combine subject knowledge and methods is emphasized repeatedly (see Web Table 1). Not surprisingly, survey respondents expected postdocs with two years of experience to have advanced level skill with formulating a scientific question (A2) and conducting literature reviews (B1), both of which are crucial for meaningful health research. Another set of competencies where advanced levels are expected pertain to validity of research such as anticipating and minimizing bias (D1), defining target, source and study population

(A3) and calculating and interpreting epidemiologic measures of disease occurrence and measures of association (F3). While the expected level for a postdoc was lower for the other competencies, it should be emphasized that only competencies considered important by the consortium made it onto the list of the 31 competencies. Thus not surprisingly, the median expected level given this stage of training for all competencies was 3 or higher, an advanced level of facility that would allow an epidemiologist to use the core competency in different situations. We should note that some caution is needed when interpreting the results as respondents may have answered according to the level attained by students in their respective programs rather than the general expectation of graduates in Epidemiology.

While many competencies are certainly relevant for both traditional health research and health research influenced by emerging trends, we identified eight competencies that are more novel and enable epidemiologists to engage in emerging trends. All of them, like the other competencies, are not topic-specific (e.g. specifically targeted at digitalization, personalized medicine or -omics) but cross-cutting for health research. This is of note as many discussions about emerging trends at the Amsterdam and Zurich meetings started with specific topics (e.g. specific, novel technologies to collect or analyze data data), in which epidemiologists may feel that researchers from other disciplines are encroaching on their role. There is also tension within the field about core goals and mission that could lead to a fracturing of the discipline.(25,26) However, the effort to define competencies described here highlighted competencies that enable epidemiologists to conduct academic health research in emerging fields in a valid, meaningful and impactful way. The knowledge of a particular technology for which an

expert may be added to the team does not define the field; nor are subdisciplines needed to address a variety of goals of health research. For example, a common theme of the discussions was the opportunity to obtain large amounts of data collected automatically or with great efficiency (e.g. through wearables, technologies to analyze large amounts of biologic specimens or digital data from everyday life) without being specific about a scientific question or hypothesis. The competencies emerging from these discussions were being able to critically evaluate and use such data sources (B3, E4) or to identify and evaluate emerging technologies in other fields (C3) to address a specific study question.

Another theme of the discussions was the nature of collaborations in health research that becomes more and more multidisciplinary with experts from fields that traditionally did not engage in health research. Also, research is increasingly initiated, conducted and translated into public health and clinical practice together with lay persons (healthy people and patients), practice partners, economists and/or policy makers. The three competencies on engaging with stakeholders to identify relevant health needs (A1), putting together multidisciplinary and well-aligned collaborations and acting as a bridge between wide-ranging health and data disciplines (O2) and seeking additional expert support (O3) emerged from these discussions. The recognition of this particular realm of competencies is consistent with recent calls for consequential science that focuses on maximizing health with an eye towards relevant outcomes as defined by stakeholders rather than researchers.(27)

While the competencies developed here may be formulated in a more specific and formal way than in previous efforts, the majority of them align well with competencies

suggested earlier. In particular, the competencies defined by the American College of Epidemiology and by the Association of Public Health Epidemiologists of Ontario share many competencies that were defined by our multi-national consortium.(11,12) The competencies for public health professionals including epidemiologists defined by public health organizations show less granularity than our competencies, which is expected given the broad field of public health that reaches much beyond the realms of academic epidemiologists.(5–11,28) Competencies for epidemiologists working in academic settings and public health professionals in non-academic settings should not be seen in any way to compete with each other, but rather guide programs that offer training for future epidemiologists in academia or public health practice settings or both.

It will require some time to recognize whether or not the competencies presented here are useful and applicable across countries and from junior to senior epidemiologists working in academia. We are optimistic that this is the case since the skills necessary to conduct meaningful and high quality health research are, for the most part generalizable across settings. Even more novel competencies are likely relevant to both high- and low- to middle-income countries, as new technologies (e.g. mobile technologies) are being deployed with great success in these settings. Thus competencies for research are likely less dependent on the setting and context than competencies for public health professionals, since health needs are highly contextual. Although we expect the competencies to be widely applicable, they are not meant to be prescriptive for academic programs. It is unrealistic to expect that any program, regardless of how well designed, could provide meaningful training in all 31 competencies to bring graduates to an advanced level for each. Rather, we consider this list as the beginning of a continued

effort to reflect on the roles of epidemiologists in academic settings and the competencies needed to conduct health research, and on the implications for curricula in epidemiology. Curriculum developers will need to consider which competencies to emphasize in a PhD program. However, programs could consider further developing existing or adding additional competencies during summer institutes, workshops or alongside annual meetings or online courses. The format of teaching and training also needs careful consideration. Some competencies can be taught in the classroom while others can only be acquired through applied research, traveling through the life cycle of a study from defining the scientific question to the communication and translation of results.

A good starting point for reflecting on the implications of the 31 competencies presented here is to analyze one's own program in terms of competencies covered and the level that may be achieved for each of the competencies (i.e. from basic to proficient). Likely, most programs will not cover all competencies and it may be difficult to judge the levels achieved. The latter is complicated by the fact that within the very same program, substantial variation across graduates and early postdocs may exist in terms of the achieved level for certain competencies; this likely stems primarily from varying opportunities given individual research projects to acquire certain competencies. Consequently, curriculum developers and faculty also need to decide for their program for which core competency they want students to uniformly achieve a certain level and for which competencies some variability is acceptable. These questions will be the subject of the 2nd International Meeting on Teaching Epidemiology and revisited often during this ongoing effort to define competencies for academic epidemiologists and

curriculum development. Competency development and curriculum reform must be a dynamic process, that acknowledges new trends and shifts in the field.

Strengths of our effort to define competencies are the carefully planned and step-wise approach, the involvement of a very diverse and multi-national group of epidemiologists, the way of organizing the meetings that made sure that all participants had a voice and avoided that single persons and views dominated the discussions, the detailed documentation of the process that always allowed going back to certain details and our effort to formulate competencies following guidance widely accepted in education. Limitations include the limited participation of epidemiologists so far from continents outside Europe and North America, as well as the preponderance of senior faculty-level health researchers in the survey. However, this latter limitation is mitigated by the fact that early- to mid-career researchers were very well represented at the Zurich meeting and very engaged in defining the set of competencies. The continued effort of the consortium also makes sure that over time, additional competencies are added and existing competencies critically reviewed and revised.

In conclusion, this is the first multi-national effort to define the competencies for epidemiologists in academic settings. The competencies proposed could serve as a base for new curricula or to update existing curricula in epidemiology.

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Table 1: Results from the online survey (May-August 2019) on the expected level of competency for a postdoc in epidemiology working in an academic setting

Mean (SD)	Median	Description of competencies
4.26 (0.90)	5	A2. Competency to formulate a scientific question and to justify the relevance of the question given the state of the evidence and a specific population health problem.
4.11 (0.92)	4	B1. Competency to plan and conduct a review of the existing, peer-reviewed literature and of other sources in order to describe the current evidence for a specific scientific question.
4.10 (0.82)	4	D1. Competency to anticipate bias (i.e. information bias, selection bias, confounding) when planning a study and to minimize its consequences for inferences through optimal study design and data analysis.
4.09 (0.93)	4	A3. Competency to define and justify the target population for addressing a given scientific question and to delineate an appropriate source population from which the study population may be sampled or recruited.
4.07 (1.02)	4	F3. Competency to calculate and interpret epidemiologic measures of disease occurrence and measures of association and their precision, and explain the importance in various specific decision-making contexts.
4.01 (1.00)	4	E2. Competency to responsibly conduct research and to align with all relevant ethical standards and laws.
3.98 (0.94)	4	B2. Competency to systematically appraise the methodological quality of existing research findings for a specific scientific question using appropriate tools and guidelines.
3.97 (1.04)	4	O3[z]. Competency to recognize when to seek additional expert support.
3.90 (0.99)	4	F4. Competency to assess the strength of evidence for a causal relationship.
3.86 (0.94)	4	E3[z]. Competency to collect valid and relevant, high quality data or to compile existing data deemed sufficiently valid for answering a specific research question.
3.84 (0.92)	4	D2. Competency to establish optimal methods for measurement, ascertainment and validation of primary study exposures and outcomes of interest, as well as important confounders and effect modifiers.
3.77 (0.98)	4	F1. Competency to select appropriate statistical methods for a specific scientific question and the available data.
3.76 (0.99)	4	C2. Competency to distinguish between prediction, and a causality framework, and plan a study and analysis accordingly.
3.74 (1.01)	4	C1. Competency to describe the distribution and occurrence of health conditions and associated risk factors, and develop the evidence regarding the population impact of associated risk factors and interventions.
3.66 (0.98)	4	B4. Given the existing evidence, competency to describe the need for new research and research to reduce uncertainty, both with respect to the specific scientific question and the methodological approach.

3.64 (1.05)	4	E1. Competency to conduct health research including the set-up, coordination, data collection, monitoring and data quality control.
3.55 (1.03)	4	C4. Competency to evaluate the appropriateness of and to plan qualitative and/or quantitative health research methods for a given study context.
3.47 (1.03)	3	E5[z]. Competency to design and work with databases.[a]
3.40 (1.05)	3	F2. Competency to work with various types of data, taking account of all relevant issues around content, database structure, quality, privacy issues and coding (meta-data).
3.36 (1.07)	3	F5. Competency to apply appropriate analytical approaches to make causal inference based on implicit and explicit assumptions
3.25 (1.15)	3	G1. Competency to effectively communicate the results of health research to health care professionals, lay public and various media and thus contribute to debates concerning health and health care.
3.24 (1.08)	3	A1[z]. Competency to engage with stakeholders and the public to identify relevant health needs from their perspective.[a]
3.18 (1.07)	3	H1. Competency to translate current evidence and knowledge to public health and health care and to appraise and guide health related questions in society from a population perspective.
3.17 (1.04)	3	D3[z]. Competency to adopt and apply new methods and study designs that may more effectively minimize inferential threats in particular study contexts.[a]
2.99 (2.99)	3	O1. Competency to prepare, obtain and manage successful grant proposals, including all scientific and administrative steps needed for submission.
2.98 (1.04)	3	F7. Competency for appropriate use for a specific diagnostic or prediction model and to develop and validate multivariable prediction models accordingly using internal or external model validation methods.
2.95 (1.19)	3	O2[z]. Competency to identify partners from various disciplines necessary to conduct health research, align partners' skills with research tasks, and act as a bridge between wide-ranging health and data disciplines[a]
2.92 (0.92)	3	B3[z]. Competency to critically evaluate the suitability, quality, and validity of existing data sources for a specific research question.[a]
2.91 (0.93)	3	C3[z]. Competency to identify emerging technologies or methodologies in other fields and evaluate their utility for a specific study question[a].
2.86 (0.93)	3	E4[z]. Competency to assess the data quality in newly collected data or existing databases and extract the data deemed sufficiently valid for answering a specific research question.[a]
2.67 (1.17)	3	F6. Competency to employ qualitative and mixed methods in health research.

[a]The [z] highlights competencies that tend not to be emphasized in traditional curricula and/or enable epidemiologists to engage in emerging trends that have an impact on health research

Figure 1: Flow chart of the process and the development of competencies. Grey boxes with round corners represent preparatory steps by the core group, white & pointed boxes with square corners illustrate publicly open core events for collecting input and decision-making and white boxes with round corners represent the development of competencies. The members of the core group are included in the number of participants, institutions and countries.

Figure 2: Five domains with 31 competencies

Figure 3: Figure plots individual competencies by their average score (y-axis; average level of competency expected for an academic postdoc in epidemiology (1 = basic to 5 = proficient)) and standard deviation (x-axis). Horizontal and vertical lines indicate overall average Likert scores and the average standard deviation across competencies. The colored clouds refer to subjectively grouped core competencies with either high Likert scores (advanced and proficient level expected) and small standard deviations (blue cluster), low to moderate Likert scores (basic to advanced level expected) and small standard deviations (red cluster), moderate to high Likert scores and moderate standard deviations (grey cluster), or core competencies with low to moderate Likert scores but comparatively large standard deviations (green cluster).