Exploring postgraduate epidemiology competencies: Preparing our students for a post-COVID world

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Abstract

Objective: This research sought consensus from both experts and graduates on postgraduate epidemiology competencies.

Methods: In 2021, a two-round online survey using a modified Delphi method was undertaken exploring competencies across six domains. Focus groups were conducted with recent postgraduate epidemiology graduates to assess their viewpoints on learning experiences and employability.

Results: Forty-one experts participated in the first Delphi round. Nineteen factors reached consensus (≥70% agreement) for importance and feasibility after two survey rounds in the following domains: general epidemiologic methods/concepts (n=8/13), advanced analytic/statistical skills (n=2/7), applied epidemiology/specialised fields (n=1/4), professional/transferrable skills (n=5/14), general public health knowledge/skills (n=2/4), independent research and work-integrated learning (n=1/3). Nine graduates participated in focus groups. A main theme was the substantial value gained in undertaking a dissertation, acknowledging its benefit for applying research skills and for networking opportunities.

Conclusions: To ensure that high-quality epidemiological research and practice continues, we need consensus on the set of essential skills required of graduating students.

Implications for Public Health: Competencies for postgraduate epidemiology students require periodic review to safeguard a workforce that can meet emerging challenges and work across academia, research, policy, and practice.

Key words: competencies, education, epidemiology, public health, training, university

Epidemiologists work in a range of settings, including government, nongovernment, universities, and research institutes. The COVID-19 pandemic has seen increased workforce demand and has resulted in a broader discussion about employer expectation on the mix of skills needed to function as an epidemiologist in these different contexts. Epidemiology is also an evolving discipline; new methods are continually emerging. In response to these challenges, it is timely to ensure that teaching aligns with the competencies required in professional practice. Developing and updating programs to ensure epidemiology students develop the skills to respond to contemporary public health challenges is important for educational institutions.

In 2014, an expert panel of teachers of epidemiology from Australia and New Zealand was convened to discuss emerging challenges faced in teaching epidemiology.[1] This resulted in broad core and advanced concepts being proposed for epidemiological practitioners and researchers. However, these were not formalised, nor consensus achieved at a national level, and debate is ongoing as to what qualifications an epidemiologist should have to be able to practice in a variety of settings.

There is a need to focus on master's-level qualifications as most training in Australia is at this level; PhD students don't complete structured coursework, as is common in the United States. Furthermore, only a few programs offer a Master of Epidemiology with epidemiology more commonly offered as a specialisation within the Master of Public Health. Work in this space is further complicated by the fact that in Australia, there is no formal program accreditation for public health qualifications in general or for postgraduate epidemiology as a discipline.

In contrast, potential competencies for master's and doctoral students in the United States have been published,[2–4] and a set of competencies for PhD graduates working in academic settings have

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recently been developed in Europe.[5] Work has also been recently published on field epidemiology competencies.[6]

To ensure that high-quality epidemiological research and practice in Australia continues, we need consensus on the set of essential skills required of graduating students. The aim of this project was to seek consensus from experts and input from students on postgraduate epidemiology competencies relevant to the Australian context.

Methods

Information was collected via two approaches: (1) a two-round modified Delphi survey with epidemiology experts and (2) focus groups among recently graduated postgraduate epidemiology students from The University of Queensland (UQ), Australia.

Modified Delphi survey

Participants

A study invitation with a link to the online survey was posted in the April edition of the Australasian Epidemiological Association (AEA) e-bulletin. The AEA is the professional organisation dedicated to excellence in epidemiological research, education, training, and advocacy in the Australasian region. There are currently 623 active members[7] who work across a range of sectors including academia and government. All members have consented to receive information of relevance to the profession via email. AEA members were encouraged to distribute the invitation email to colleagues as a snowballing recruitment strategy. A reminder email was sent two weeks following the initial invitation for each survey round (i.e., round 1 was open for the month of April 2021; round 2 was open for the month of May to June 2021).

Data collection

Competencies for epidemiologic training were identified from a review of the literature and an environmental scan of graduate attributes commonly listed on Australian university institution websites; 40 factors across six domains were included in the first survey round. In each round, participants were asked to indicate the level of agreement for importance (i.e., for students to develop each concept/skill) and feasibility (i.e., of teaching each of these concepts/skills in a typical Master of Epidemiology degree of 1.5 to 2 years full-time duration). The five-point Likert scale for importance ranged from 1 = no importance to 5 = most important. The five-point Likert scale for feasibility ranged from 1 = no feasibility to 5 = always/very feasible. In the first round, a free-text field was included following each domain and at the end of the survey for participants to provide suggestions for other relevant factors in the subsequent survey round. The first survey round also collected information on demographics and professional background. Participants received the results of round 1 analysis before the subsequent round as a means of feeding back the level of agreement achieved.

In the second round, participants were asked to review and rerate the factors where consensus was not met, as well as newly identified factors from round 1. A free-text field for comments was not included in the second survey. Each survey took approximately 20 minutes to complete via a secure online platform (Checkbox) between April and June 2021.

Analysis

In line with a standardised, predetermined approach for analyses, the top two categories for importance ("most important" and "high importance") were combined, as were the top two categories for feasibility ("usually feasible" and "always/very feasible"). Consensus was achieved when at least 70% of participants scored a factor as most/high important and usually/always/very feasible. Round 1 survey ratings and accompanying free-text comments were stratified by work sector (university teaching and research; university research only; government; other/nongovernment). The differences in consensus reached by at least 70% for importance (high/most important) and feasibility (usually/always/very feasible) were then explored by work sector. Free-text comments were reviewed to explore reasons for these differences by respondents from different work sectors.

Graduate focus groups

Participants

Graduates were purposively recruited via email from lists of alumni who had provided consent to be contacted post-graduation. UQ alumni, both international and domestic, who recently (up to three years) graduated with a postgraduate coursework epidemiology qualification were invited to participate in a focus group.

Data collection

Participation involved taking part in one focus group consisting of a semi-structured discussion regarding competencies that graduates viewed as being important for developing skills for employability. Four sessions ($\leq$1 hour each) were conducted via Zoom in April 2021 and were led by one of the research investigators (RJ). Focus groups were recorded and transcribed, and comprehensive field notes were taken by the facilitator. Transcriptions and facilitator notes were cross-checked for accuracy to derive full and accurate quotes.

Analysis

To analyse the focus group data, two members (TD, RJ) of the research team independently conducted a thematic analysis using interpretive description of the transcriptions and facilitator notes.[8] This involved independently reading the transcripts, generating codes, and collating these into broader themes and concepts. The themes were then compared and reviewed by discussion between the two members of the research team to gain consensus.

Results

Modified Delphi survey

A flowchart outlining the process of the two-round modified Delphi survey is presented in the Supporting Information (SI Figure 1). A total of 41 experts participated in the first survey round. Participant demographics and professional background are presented in Table 1. Participants had a range of years of experience working as an epidemiologist (<5 to >10 years) across different sectors, including university (70.7%) and government (14.7%). Most participants were from Australia (95.2%); other locations included New Zealand and Hong Kong.

Table 1: Modified Delphi survey (experts) participant demographics (N=41).

Characteristics	n	%
Year's experience as an epidemiologist		
0-<5	7	17.1
5-<10	11	26.8
10+	23	56.1
Main sector of work		
Government	6	14.7
Nongovernment	2	4.9
University, research only	13	31.7
University, teaching and research	16	39.0
Other	4	9.7
Location		
Australia	39	95.2
Other	2	4.8

Findings from round 1

Results from the Delphi survey are presented in Table 2. The column labelled round 1 lists the results for the importance and feasibility of 40 factors included in the first round; the grey shaded cells indicate competencies that were not included at this time point.

Seventeen factors reached consensus for importance and feasibility in the first survey round. Review of the round 1 comments in relation to possible new factors resulted in the identification of four additional factors: data visualisation (general epidemiologic methods domain); understanding of government and the Australian health care system, and skills to support ongoing self-directed learning (transferrable/professional skills domain); professional workplace conduct (work-integrated learning). One factor was separated into two distinct skills: health promotion and health evaluation. Three factors that were considered not important (<30% for importance) were removed: preparation of grant proposals, propensity scores, and genetic epidemiology.

Importance and feasibility: consensus after two rounds

The column labelled round 2 of Table 2 lists results for the 25 factors included in round 2; the shaded cells indicate competencies that were not included at this time point. Competencies in bold, italicised text in Table 2 are those reaching consensus for both importance and feasibility, at completion of the Delphi process.

Twenty-eight (68.3%) of the 41 experts who initially completed the first survey also completed the second survey. An extra two factors reached consensus for importance and feasibility, resulting in a total of 19 factors after two survey rounds. The level of consensus for each factor is presented in Table 2.

In total after two survey rounds, 24 factors out of a total of 45 unique factors (n=24/45) were identified as important. This result is shown within domains as follows: general epidemiologic methods and concepts (n=8/13), advanced analytic/statistical skills (n=2/7), applied epidemiology/specialised fields (n=1/4), professional/transferrable skills (n=10/14), general public health knowledge/skills (n=2/4), independent research, and work-integrated learning (n=1/3).

Five factors (engage with stakeholders, project management, knowledge translation, work as a member of a multidisciplinary team, and skills to support ongoing self-directed learning) reached consensus for importance but not feasibility. Two factors (data visualisation and causal inference methods for confounding, effect modification, mediation) were considered feasible but did not reach the predefined level for importance.

Responses by work sector

Figure 1A and B show factors where there was disagreement in the competencies considered important across work sectors with accompanying quotes collected in the first survey (Supporting Information Table 3). Disagreement across work sectors was defined as consensus being reached (i.e., at least 70% of participants within a work sector rated as high/most important) within some work sectors but not others. Differences in consensus across work sectors were only explored using round 1 data, due to the higher response rate. Note that 40 competencies were included in the first survey round; therefore, the total number of factors differs from the results shown above for the second survey.

General epidemiologic methods and concepts (12 factors): Five factors reached agreement for importance across all work sectors, including development of a research question, conduct a review of the existing literature, critical appraisal of the literature, theoretical understanding of bias and confounding, and causal inference thinking. These factors were the only ones to reach consensus by participants working in the government sector. All except causal inference thinking also reached agreement across sectors for feasibility. Consensus was mixed across sectors for the importance of study design, research protocol development, survey design, population sampling methods, sample size, and directed acyclic graphs (with government participants scoring the lowest ratings for importance).

Advanced analytic/statistical skills (7 factors): Consensus was mixed across sectors for the importance of statistical software skills, regression analyses, causal inference methods, and methods to deal with missing data. One factor reached agreement for feasibility (regression analyses). An emerging theme in the free-text comments regarding the inclusion of epidemiologic skills (general and advanced) was that of distinguishing the importance of epidemiological skills versus transferrable skills (Supporting Information Table 3).

Applied epidemiology/specialised fields (4 factors): Consensus was mixed across sectors in terms of importance and feasibility were identified for disease surveillance and outbreak management, with greater proportions of experts from government and nongovernment sectors rating these factors as important, compared with those from the university sector.

Professional/transferrable skills (12 factors): Five factors reached agreement for importance across work sectors including scientific writing, oral communication, data management ethics, and work as a member of a multidisciplinary team. Two of these factors (scientific writing and ethics) also reached agreement for feasibility. Consensus was mixed across work sectors were reported for engaging with stakeholders, conducting literature reviews, project management, and knowledge translation.

General public health knowledge/skills (3 factors): One factor (social determinants of health) reached agreement for importance and feasibility across all sectors. The importance of Indigenous health (including data sovereignty) reached agreement across sectors except for government although there was agreement that this factor was feasible.

Table 2: Round 1 and 2 survey results for importance and feasibility of teaching competencies in a postgraduate degree

Factor	Round 1, %		Round 2, %	
	Importance[a]	Feasibility[b]	Importance[a]	Feasibility[b]
General epidemiologic methods and concepts				
Development of a scientific question	97.6	92.7	—	—
Conduct a review of the existing literature	87.8	90.2	—	—
Critical appraisal of the literature	97.6	90.2	—	—
Study design concepts	90.3	90.2	—	—
Research protocol development	65.9	70.7	85.7	85.7
Survey design	63.4	70.7	64.3	85.7
Determine appropriate population sampling methods	75.6	73.2	—	—
Determine the appropriate sample size	63.4	80.0	60.7	85.7
Theoretical understanding of bias and confounding in epidemiological studies	100.0	95.1	—	—
Causal inference thinking	85.4	75.6	—	—
Directed Acyclic Graphs (DAGs)	52.5	62.5	53.6	64.3
Clinical Epidemiology (diagnostics; prognostics; RCTs)	32.5	70.7	39.3	78.6
Data visualisation	—	—	67.9	92.9
Advanced analytic/statistical skills				
Fundamental programming skills in ≥1 statistical software package	78.1	75.6	—	—
Regression analyses	87.8	97.6	—	—
Causal inference methods for confounding, effect modification and mediation	68.3	78.1	67.9	75.0
Quantitative bias analysis	43.9	60.0	50.0	64.3
Longitudinal data analysis	48.8	57.5	57.1	75.0
Propensity scores	24.4	38.5	—	—
Methods to deal with missing data	57.5	50.0	42.9	70.4
Applied epidemiology/specialised fields				
Disease surveillance	68.3	75.6	71.4	89.3
Outbreak Management	56.1	65.9	42.9	57.1
Spatial Epidemiology	34.2	51.2	17.9	64.3
Genetic Epidemiology	17.1	39.0	—	—
Professional/transferrable skills				
Scientific writing	95.1	85.4	—	—
Oral communication	87.8	82.9	—	—
Preparation of grant proposals	26.8	31.7	—	—
Advocacy	46.3	22.0	32.1	46.4
Engage with stakeholders	68.3	22.0	82.1	35.7
Conducting literature reviews	80.5	95.1	—	—
Project management	70.7	41.5	82.1	67.9
Data management	85.4	78.1	—	—
Ethics	82.9	85.4	—	—
Systems thinking	46.3	41.5	57.1	57.1
Knowledge translation	63.4	29.3	78.6	57.1
Work as a member of a multidisciplinary team	87.8	41.5	89.3	39.3
Understanding of government and the health system in Australia	—	—	60.7	78.6
Skills to support ongoing self-directed learning	—	—	78.6	67.9
General public health knowledge/skills				
Indigenous health including data sovereignty	82.9	82.9	—	—
Social determinants of health	92.7	95.1	—	—
Health promotion/evaluation	61.0	87.8	—	—
Health promotion	—	—	39.3	78.6
Health evaluation	—	—	57.1	82.1
Independent research and work-integrated learning				
Independent research (research dissertation/project)	80.5	72.5	—	—
Work-integrated learning (work placements)	65.9	36.6	64.3	35.7
Professional workplace conduct	—	—	46.4	21.4

Cells shaded grey indicate a competency not included in a given round due to consensus being reached in round 1 or new competencies being added in round 2.

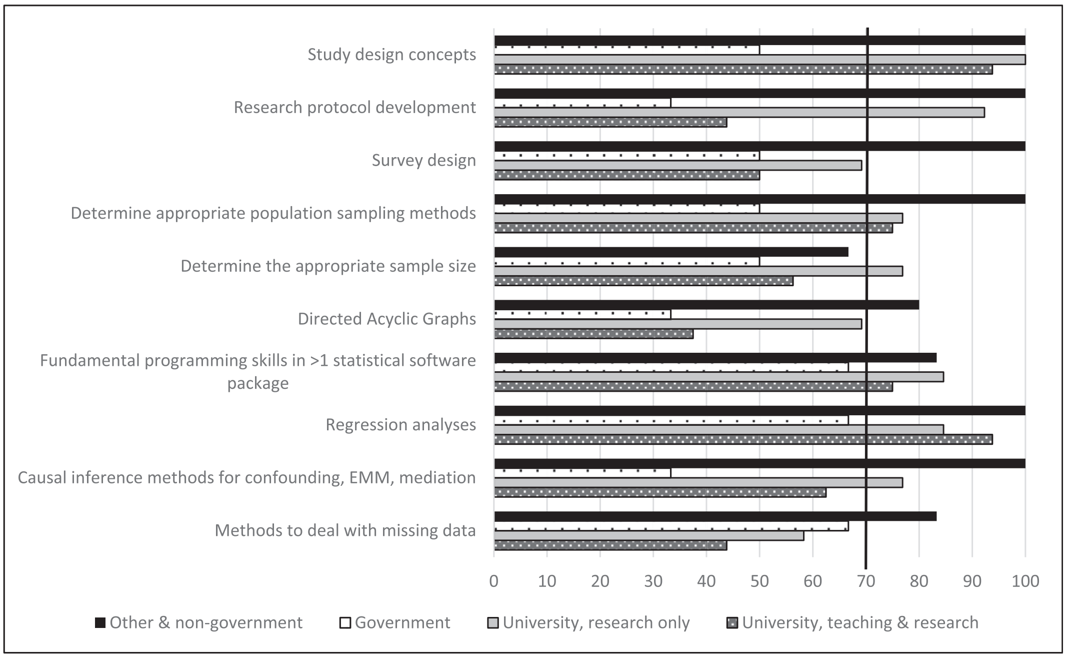
Competencies in bold italicised text are those reaching consensus after two rounds for both importance and feasibility.

[a]Importance of "high importance" and "most important" combined.

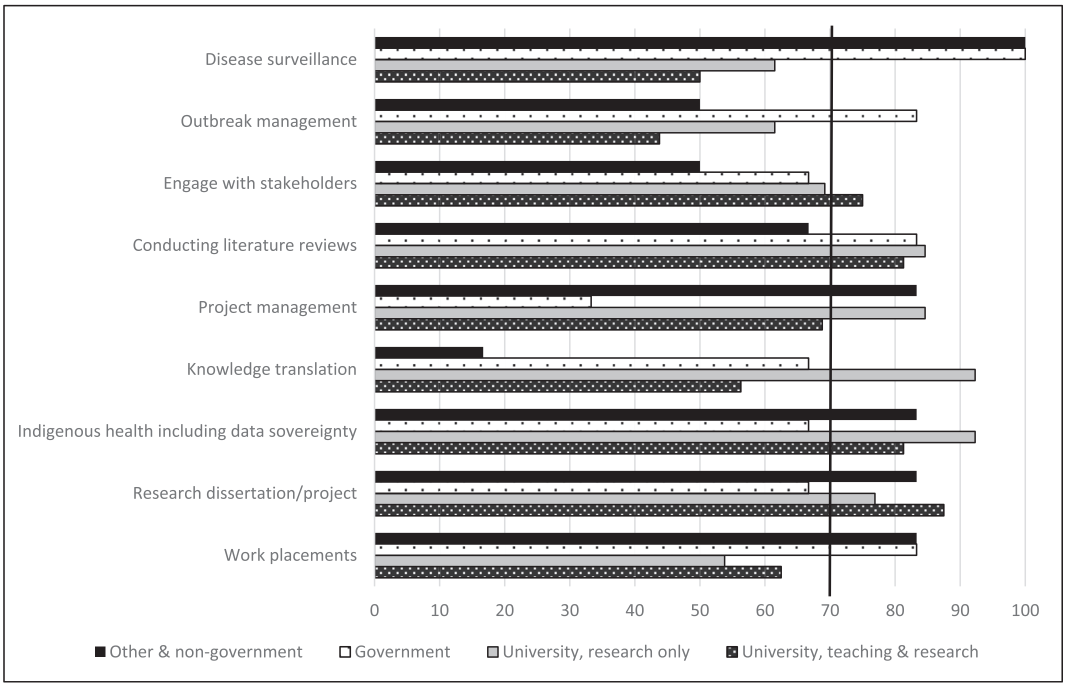
[b]Feasibility of "usually feasible" and "always/very feasible" combined.

Figure 1: A) Percentage of each competency receiving a score of 'most/high importance' by work sector for the following domains: general epidemiologic methods/concepts and advanced/analytic statistical skills. B) Percentage of each competency receiving a score of 'most/high importance' by work sector for all other domains.

A



B



Independent research and work-integrated learning (2 factors): Consensus was mixed across work sectors for both factors in this domain. Government participants reached consensus for the importance of work placements (83.3%) over the research dissertation (66.7%). University (both teaching and research, and research only) reached consensus for the importance of the research dissertation (87.5% and 76.9%, respectively) over work placements (62.5% and 53.8%, respectively).

Graduate focus groups

Nine recent UQ graduates participated in focus groups and had completed either a Graduate Diploma in Epidemiology (n=1) or the Master of Epidemiology (n=8). Focus group participants were representative of the broader recent graduate cohort in terms of average age (34.8 vs. 31.2 years, respectively), residential status (domestic: 77.8% vs. 81.5%), and study load (full-time: 44.4% vs. 44.5%).

The major themes for topics/competencies that recent graduates found most beneficial in developing skills for employability were the dissertation, using a statistical package, consolidating literature searching and preparation of literature reviews, and critical thinking. In particular, the dissertation was viewed as a practical application of the skills learnt during coursework (Supporting Information Table 4, P05). Graduates recalled the most difficult competency to develop and demonstrate was using a statistical package, which was often a new skill (Supporting Information Table 4, P02).

Focus group participants also identified professional/transferrable skills that they would have liked more time to develop, including the need for project management, including data management specific to epidemiology; a focus on professional pathways (beyond the current focus on research pathways); connections with alumni; and more skills in applying for jobs such as communications skills (Supporting Information Table 4, P01).

Discussion

The COVID-19 pandemic has increased demand on the public health workforce and created numerous job opportunities for epidemiologists, highlighting the need for consistency in graduate competencies across education and training programs. This study reached expert consensus on a set of postgraduate epidemiology competencies relevant to the Australian context and, in addition, considered these alongside competencies identified by graduates. A survey of experts identified 19 factors considered to be important and feasible to deliver in a 1.5 to 2-year postgraduate epidemiology degree. A main theme that emerged from the graduate focus groups was the substantial value gained in undertaking a dissertation, acknowledging its benefit for applying research skills and for networking opportunities.

In our modified Delphi survey, general epidemiologic methods and a range of professional/transferrable skills were regarded as important competencies for postgraduate epidemiology students, with 61.5% (8/13) and 71.4% (10/14) of factors achieving expert consensus in the respective domains. However, there was some variability in ratings given by experts in different work sectors. This is an important consideration in curriculum development to ensure job-ready graduates for a range of settings. Results by work sector should be interpreted with caution due to the low numbers outside the university setting; however, a key implication is the need to balance foundational competencies, advanced skills, and professional skills to match current and future workforce requirements.

Foundational competencies include a broad understanding of public health principles, in addition to epidemiology skills, to ensure graduates are equipped to respond appropriately to emerging challenges. General public health competencies, including social determinants of health and Indigenous health, reached consensus in the first Delphi round recognising this importance. Although our survey focused on the Australian context, we regard Indigenous health, including data sovereignty, to be an important and emerging competency globally. In Australia the National Aboriginal and Torres Strait Islander Public Health Curriculum Framework[9] defines core principles to guide the development of culturally appropriate public health curricula, and these also apply to epidemiology programs.

Based on an initial literature review and environmental scan of Australian graduate attributes, we considered it was important for graduates to understand the entire research process from study design, ethics, data collection, data management, to analysis, and dissemination. For the most part, these competencies were confirmed; although survey design and determining sample size did not reach consensus for importance, only 12.2% and 2.4% rated these factors as low importance, respectively (none rated as no importance). Our analysis by work sector suggests that these skills are valued in research-intense settings (university research only and other/nongovernment). Furthermore, survey design was not found to be a common competency identified in the literature,[2–5] while determining the appropriate sample size was considered important at the doctoral level.[2,4] These findings may reflect differences in the day-to-day work of epidemiologists across different settings, with academic epidemiologists frequently consulted in the design and initial stages of research projects, compared to higher demand in government settings for practical analyses and disease surveillance skills (which may have been even more apparent than previously, as the survey was conducted during the pandemic). Interestingly, graduate students highly valued the opportunity to apply research skills through completion of a dissertation.

With regards to job demand, trends over time until 2016 demonstrate that more than two-thirds of jobs listed general research skills, and more than a quarter of jobs listed a statistical software package, with lower proportions listing specialised areas such as surveillance (28.8%) or outbreak (7.7%).[10] Not surprisingly, job postings in the United States during the COVID-19 era (March 2020 to October 2020) compared to pre-COVID (March 2019 to October 2019) increased significantly for epidemiologists and statisticians,[11] which we assume could be for disease surveillance and outbreak work.

A search of the international literature reporting postgraduate epidemiology competencies identified four articles, in addition to our study (Supporting Information Table 5). Two studies were conducted in the United States,[2,3] one in the United States and Canada,[4] and one multinational (19 different countries) consortium.[5] Competencies were identified at master and doctoral,[2] doctoral,[3,4] and postdoctoral[5] levels. Data were collected from established epidemiologists,[2,5] recent master/doctoral graduates,[2] the epidemiology community,[5] doctoral program directors/chairs,[4] and from publicly available information.[3]

Five competencies were identified as important by all five studies including: development of a scientific question, study design concepts, fundamental programming skills in $\geq$1 statistical package [data analysis], communication, and ethics. A further four competencies were identified by four out of the five studies: critical appraisal of the literature, theoretical understanding of bias and confounding, scientific writing, and data management.

Hlaing (2020)[4] reported on emerging topic-related competencies, including grant writing, causal inference concepts (such as directed acyclic graphs), and working as a member of a multidisciplinary team. Grant writing was not found to be important or feasible in our study, with one expert participant saying that many skills can only be learnt on the job, including grant writing and multidisciplinary teamwork. Experts in our study rated causal inference thinking as both important and feasible, although this was not found for the use of more modern causal inference methods, including the use of directed acyclic graph. It is unclear whether these findings reflect a lack of need for these skills in the workforce (unlikely, particularly in an academic setting) or a lack of competency and understanding of the importance of these contemporary approaches to causal inference by survey respondents, many of whom may have trained before these techniques became widely accepted.

The strengths and limitations of our work should be considered. Our modified Delphi and focus groups had small sample sizes but included a good representation of experts across different work sectors, and graduate students who participated in the focus groups were representative of the broader student cohort. Furthermore, graduates had completed their degree within the previous two years, therefore minimising the likelihood of recall bias. Although our Delphi survey used a predetermined set of competencies derived from the literature, we were not limited by this, and utilised free-text fields included in the first survey round to incorporate newly identified competencies in the second round. However, the list of competencies is unlikely to be exhaustive, for example, leadership/management skills were not identified in our study, although is frequently (52.3%) listed in job postings.[10] In addition, we were not able to establish from the Delphi study why some competencies rated as important were not considered feasible to include in a postgraduate curriculum; the reasons for this should be explored in future research.

The implications of this work are relevant to teaching and the professional practice of epidemiology. Results should inform authentic curricula development within epidemiology programs throughout Australia, which facilitates acquiring the essential knowledge and skills that are necessary in practice. Importantly, experts highlighted the need for Epidemiologists to be able to communicate complex issues in a clear way and advocate for change and good policy, yet these skills are not formally taught. Results from this Delphi consensus will be disseminated through the AEA, as well as directly to other Australian Universities currently teaching Epidemiology and Public Health programs through the Council of Academic Public Health Institutions Australasia, to inform future redevelopment of courses and programs.

Our study used information from diverse sources which enabled an in-depth exploration of competencies for postgraduate epidemiology training that is expected by students and experts across different work sectors of the health system. To ensure that high quality epidemiology research and practice continues, these competencies can now be used to inform the review and development of epidemiology curriculum. This, in turn, will safeguard our workforce to tackle our most pressing public health issues.

Ethics

Ethical approval was obtained through The University of Queensland Human Research Ethics Committee (approval number 2020/HE002966).

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None.

Conflicts of interest

The authors have no competing interests to declare.

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Appendix A Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anzjph.2023.100026.