AUSTRALIAN GENOMICS

GENOMIC WORKFORCE, EDUCATION & ETHICS

Technical Report

Mapping Existing Education & Training for the Australian Clinical Genomic Workforce

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Key Findings

- Genomic education activities produced in Australia were identified in 2016–17 via systematic Google searches and review of relevant professional organisation and college websites and newsletters. Desktop data were supplemented by interviews with education experts and program convenors.
- Fifty-nine ongoing programs of genomic education relevant to health were identified across three categories: 20 university postgraduate courses/subjects; 37 substantive programs, and 2 massively open online courses (MOOCs).[1] Of these, 81% were national, New South Wales or Victorian based. Undergraduate university subjects or courses and programs not developed in Australia were outside the scope of this research.
- Very few education providers had formal education qualifications; the majority had a doctorate and a third had clinical qualifications.
- Many programs did not have an online presence and were identified through interviews or professional organisation membership emails or newsletters. Details of these programs were only gained through further interviews with conveners.
- Programs appear to have developed in response to the introduction of new technology, rather than there being an overarching approach to genetic or genomic education that is able to incorporate new technologies as they emerge.
- There are two university award programs in clinical genomics in Australia, with three more due to launch in 2018/19, including laboratory diagnostics.
- Substantive programs collectively spanned basic genetics and genomics, screening and testing technologies, pharmacogenomics, variant curation and interpretation, and application of genomics to local health system contexts.
- Programs were targeted at varied audiences, commonly general, clinical or laboratory, and some for the general public. However, convenors noted that attendees often extended beyond the target audience and were often multidisciplinary. While programs are best designed to meet the needs of the target audience, ensuring programs acknowledge upfront that a varied and wide audience may be interested to participate will promote and provide access to a range of professions.
- Members of the general public access introductory-level online resources and courses on genetics, genomics, ethics and social issues.
- As genomics is a fast-moving field, new education programs have emerged since this mapping. The methodology allows future rigorous data collection and reporting, noting direct contact with conveners is necessary to supplement online information.
- This methodology does not assess program quality or suitability for target versus actual audiences. That work is part of ongoing Australian Genomics Genomic Workforce Education research.
- Future directions for clinical genomic education in Australia include improving information available online about relevant activities and resources, considering multidisciplinary audiences when designing activities and resources, and establishing an evidence base to guide appropriate, high quality clinical genomics education.

[1] Ongoing programs of genomic education were defined as those likely to be retained or built upon in the foreseeable future. University award programs included postgraduate subjects or courses available to both enrolled students and as stand-alone subjects for university credit. Substantive programs were programs and resources suitable for CPD, such as workshops, podcasts, case studies, etc. Massive Open Online Courses (MOOCs) are open to anyone, spanning health professionals to public audiences. All terms and acronyms are defined on page 5 of this report.

Table of Contents

Key Findings 3
Table of Contents 4
Figures and Tables 5
Acronyms and Terminology 6
Australian Genomics Workforce, Education & Ethics Research 8
Purpose 9
Scope 9
Study Design 10
Findings 10
- Characteristics of interviewed convenors 10
- Genomics education activities 11
- Target audiences 11
  - Clinical bioinformaticians 12
  - Genetic professionals – clinical 12
  - Genetic professionals – laboratory 13
  - Medical scientists 13
  - Non-genetic health professionals 13
  - Mixed audiences 14
  - Other stakeholders with an interest in genetics 14

Limitations 15
Future Directions 16
  - Improve information available online about relevant genomic education 16
  - Consider multidisciplinary audiences when designing genomic education activities 16
  - Establish an evidence base to guide appropriate, high quality genomics education activities 16

Appendix A: Detailed Methods 17
- Research governance and design 17
- Website and internet searches 17
  - Medical colleges website searches 17
  - Human Genetics Society of Australasia website search 18
  - Google search 18
- Working Group input and genomic education activities shortlist 20
- Key informant selection and interviews 21

Appendix B: Methods to Identify and Verify Education Activities 22
Appendix C: Content of Genomic Education Activities 28

Figures and Tables

Figure 1. Australian Genomics programs, flagships, clinical outcomes and analyses 8

Figure A- 1. Program logic for genomic education activity mapping in Australia 17
Figure A- 2. Systematic review process to identify activities through Google search 20

Table 1. Project scope: education content, structure and location 9
Table 2. Education activity by education category 11
Table 3. Education activities by location and/or reach of host organisation 11
Table 4. Education activity category by target audience 11

Table A- 1. Inclusion and exclusion criteria for Google search results of genomic education activities 19
Table A- 2. Original means by which education activity identified 20
Table A- 3. Rubric to describe genomic education activities 21

Table B- 1. Details of how postgraduate courses and subjects were identified and verified 23
Table B- 2. Details of how substantive programs and ad hoc resources were identified and verified 24
Table B- 3. Details of how MOOCs were identified and verified 25
Table B- 4. Details of Google keyword search outcomes for education and training activities and resources related to genomic medicine 26

Table C- 1. Details of postgraduate courses and subjects sorted by title, including organisation, including location, content, delivery and audience 29
Table C- 2. Details of substantive programs and ad hoc resources sorted by title, including host, location, content, delivery and audience 31
Table C- 3. Details of MOOCs, including host, content, delivery and audience 38

Acronyms and Terminology

Acronym	Term	Definition
AACB	Australian Assoc. of Clinical Biochemists	
AACG	Australasian Association of Clinical Geneticists	
ABCBS	Australian Bioinformatics and Computational Biology Society	
ASDG	Australasian Society of Diagnostic Genomics	
ASGC	Australasian Society of Genetic Counsellors	
ISCB	International Society for Computational Biology	
KCCG	Kinghorn Centre for Clinical Genomics	
VCGS	Victorian Clinical Genetics Services	
	Clinical genomics	The study of complete sets of DNA including structure, function, evolution, mapping, and associated technologies, as applied to health care
CPD	Continuing professional development	Any education or training activities designed to be undertaken after and/or outside official qualification or accreditation requirements, that may or may not be officially recognised by the relevant professional body Also includes discipline-specific terms such as Continuing Medical Education (CME) for medical specialists and Maintenance of Professional Standards (MOPS) for genetic counsellors; programs of this nature must fulfil standard educational program requirements, e.g., identifying needs, clear learning objectives and evaluation included
	Education	Programs where participants receive information and may or may not include hands-on components such as learning to use specific software programs; this may include CPD/CME/MOPS activitiess
F2F	Face-to-face	In person activity, as opposed to purely online synchronous or asynchronous learning. Some programs may be blended, i.e., at least some in- person contact plus online learning
	Genetic health professional	Clinical geneticists, genetic counsellors, medical specialists with genetics expertise
	Genomic Workforce, Education & Ethics	Full title of the Australian Genomics program of research. When relevant in this report, abbreviated to "Genomic Workforce Education" or "Genomic Ethics" research
	Genomic education	Courses, subjects, activities and/or resources with curricula that cover genomics, including those specific to health contexts, such as genomic medicine or clinical bioinformatics
	Genomics	The study of complete sets of DNA including structure, function, evolution, mapping, and associated technologies
HGSA	Human Genetics Society of Australasia	Professional organisation for people trained or working in human genetics in Australasia, including genetic counsellors, clinical geneticists, genetic pathologists, medical scientists and laboratory specialists, clinical bioinformaticians, ethicists, lawyers, educators and policy makers

Acronym	Term	Definition
	Laboratory genetic specialists	Genetic pathologists and elite medical scientists with advanced training in genetics and genomics.
MOOC	Massive Open Online Course	A free course available over the Internet to an unlimited number of people. There are usually no minimum requirements to enrol in a MOOC, i.e., courses can be completed by both professionals and lay people, with content written for varied audience levels. Some MOOCs embed self-assessment activities and/or offer Certificates of Completion for a small fee
	Medical scientists	Scientists who perform medical laboratory tests to provide information for diagnosing, treating and preventing disease and may also conduct research. May specialise in haematology, cytology, molecular genetics or genomics, for example, variant prioritisation and curation in collaboration and levels accredited by the Royal College of Pathologists of Australasia
MDT	Multidisciplinary team meeting	Clinical meetings where clinical and laboratory staff come together to discuss patients and/or test results. May also include non-genetic health professionals
	Non-genetic health professionals	Health professionals who have not untaken training in specific knowledge and counselling in genetics but whose role will be impacted by genomics, such as medical specialists, general practitioners, allied health professionals, nurse and midwives
RACP	Royal Australasian College of Physicians	Medical college responsible for training and accrediting physicians in Australasia, including clinical geneticists
RANZCOG	Royal Australian and New Zealand College of Obstetricians and Gynaecologists	Medical college responsible for training and accrediting obstetricians and gynaecologists in Australasia
RACGP	Royal Australian College of General Practitioners	Medical college responsible for training and accrediting general practitioners in Australasia
RCPA	Royal College of Pathologists of Australasia	Medical college responsible for training and accrediting pathologists in Australasia, including genetic pathologists, who may gain dual training in clinical genetics
	Substantive programs	Separate and independent ongoing programs and resources suitable for CPD (workshop, podcast, case study) but not an official education or training activity. This may include a lecture series where a particular topic may or may not be repeated but the program may include other genomics topics in the future
	Training	Any activities required to achieve certification and/or accreditation by the relevant professional body, e.g., the medical colleges' trainee programs Also includes workplace-integrated learning activities, apprenticeships, secondments and placements
	University subjects, courses or programs	Post-graduate subjects or courses provided by universities, usually taken as part of a degree but in one instance could be taken as a stand-alone subject. Undergraduate university subjects or courses are outside the scope of this definition and report

Australian Genomics Workforce, Education & Ethics Research

Australian Genomics brings together 80 partner organisations committed to integrating genomic medicine into healthcare in Australia. Australian Genomics was awarded a $25M National Health and Medical Research Council (NHMRC) Targeted Call for Research Grant, from 2016–2020, to:

- Demonstrate how Australians can benefit through the use of genomic data in one or more diseases.
- Provide evidence on the cost effectiveness of implementing genomics into the Australian health system.
- Provide practical strategies that can be used by Australian health system planners and policymakers to integrate genomic medicine into healthcare.
- Build Australia's research expertise in genomics.

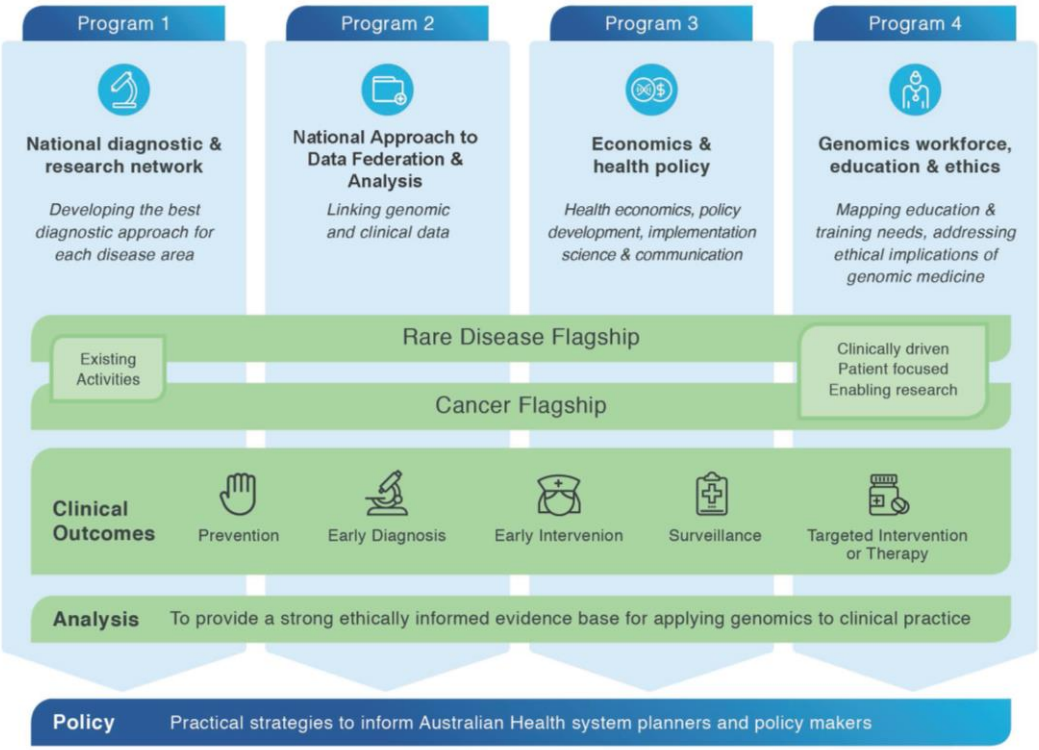


Figure 1. Australian Genomics programs, flagships, clinical outcomes and analyses

The Genomics Workforce, Education & Ethics research program seeks to understand the education and training needs of those whose role will be impacted by genomics. The patient perspective will also be considered, along with ethical, legal and policy issues. A wide range of perspectives will be obtained by engaging broadly across diverse health professional networks, in the different states and territories of Australia, as well as understanding patient perspectives.

Purpose

The first project of the Genomic Workforce Education research program of Australian Genomics was to map current and planned genomic education activities available in Australia. This project:

- enables health professionals to identify appropriate education activities that will allow them to develop their competence in genomics;
- informs education providers and education policy officers when designing genomics education programs in the future to consider and address education gaps, and to identify opportunities to build on existing programs,
- informs strategies to build workforce capacity in areas of known workforce shortage, such as genetic counselling and clinical bioinformatics, by identifying current and needed training activities ; and
- provides a baseline to monitor change in educational activities.

This Technical Report presents a comprehensive summary of the desktop mapping of relevant activities, with detailed results presented in appendices.

The report is designed to inform future work synthesising the outcomes from across the Genomic Workforce Education program (e.g., recommendations to specific audiences, white papers, academic papers).

Scope

Table 1 summarises the project scope, defining the project in terms of content, structure and location of education activities considered in or out of scope.

Table 1. Project scope: education content, structure and location

Education activity	In scope	Out of scope
Content	Genomics, *i.e.*, the study of complete sets of DNA including structure, function, evolution, mapping, and associated technologies	Genetics, *i.e.*, the study of heredity and the effect of single gene polymorphism on function.
Type	Ongoing or more permanent programs of genomic education, likely to be retained or built upon in the foreseeable future, *i.e.*, • Postgraduate university subjects that can be taken with or without full enrolment in a postgraduate program[1] • Substantive ongoing programs suitable for CPD • Massive Open Online Courses (MOOCs) produced in Australia	Once-off events or regular 'in house' work place events, *i.e.*, • Multidisciplinary team meetings (MDTs) • Grand rounds and journal clubs • Other "business as usual" training and education on the job • Training for consumers of proprietary software or products
Location[2]	Activities developed and hosted in Australia	Host institutions located out of Australia Activities offered overseas by organisations based in Australia

[1] One subject was identified as being open to people not enrolled in a degree and one third year undergraduate subject was included as it is completed by clinical geneticists as part of their advanced training.

[2] Although quality education programs are available overseas, especially in the UK and USA, this work aimed to focus primarily on activities available within Australia as they would be most relevant to the Australian healthcare context and more useful when planning future educational activities in Australia.

Study Design

For detailed methods see Appendix A.

Desktop research first involved targeted searches of websites of key health provider education and accreditation bodies, including the Royal College of Pathologists of Australasia (RCPA), Royal Australasian College of Physicians (RACP), Royal Australian College of General Practitioners (RACGP), Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG), and the Human Genetics Society of Australasia (HGSA).

This targeted search was supplemented by 17 sequential Google keyword searches (see Appendix A for search terms) to identify additional genomics education activities taking place in Australia.

Data were also systematically collected on existing or planned genomic education activities in Australia from structured interviews with Australian Genomics Workforce Education & Ethics Working Group members (see Appendix A).

From these data sources, a list of in-scope activities was generated. A rubric of case fields was created and used to describe and document genomic education activities:

- Name
- Subject code (where applicable)
- Host organisation
- Brief summary of content
- Recommended prior knowledge or skills
- Delivery method
- Evaluation
- Audience (intended vs. actual)
- Certification
- Status

Information gleaned online was complemented where possible by data gathered in a short, structured interview with the convenor of each educational activity. Convenors provided verbal consent to participate in the interview and data were confirmed by the convenor of each activity post-interview.

Findings

This Technical Report provides a snapshot of activities available to Australian health professionals in late 2016.

Fifty-nine education activities or resources were identified Australia-wide (Table 2), with details of how each was identified provided in Appendix B. To supplement limited data available online for each activity, additional information was obtained by interviews with 32 convenors on 39 of the identified activities. For other activities, there was either no response from individual convenors, or a convenor could not be identified, so the dataset for those activities was populated solely from website content.

Our experience confirms that direct contact with conveners is necessary to supplement online information. Therefore, the methodology described in detail provides a basis for future rigorous data collection and reporting.

Detailed information about each activity from both desktop research and (where available) the relevant convenor is provided in Appendix C and summarised below.

Characteristics of interviewed convenors

Of 32 convenors interviewed, 9 had clinical qualifications (genetic counselling, medical specialty, nursing or allied health), 4 had pathology qualifications, and 24 had a doctorate in science, social science or bioinformatics. Many had dual qualification with a mix of science/medicine/allied health (9) or education (4).

Genomics education activities

An initial review of the full list of education activities revealed three broad categories (Table 2).

Table 2. Education activity by education category

Education category	Description	n
Postgraduate course/subject	Postgraduate university course (Master, Graduate Diploma, Graduate Certificate level) or individual subject units (which may be 3rd year level)	20
Substantive programs and resources	Substantive ongoing program (workshop, podcast, case study) or resource suitable for CPD	37
MOOC	Massive Open Online Course	2
TOTAL		**59**

Table 3 shows the geographical location and/or reach of organisations that developed the activity by education activity category. National reach was defined as organisations with either national funding or specific national remit, such as medical colleges or professional associations. Most activities are offered in NSW and Victoria, with no activities specifically offered in the Northern Territory or Tasmania. Only two MOOCs are produced in Australia.

Table 3. Education activities by location and/or reach of host organisation

Education category	National[1]	ACT	NSW	QLD	SA	VIC	TAS	WA	Total
Postgraduate course/subject	0	0	7	1	2	6	0	4	**20**
Substantive program	13	1	9	2	0	11	1	0	**37**
MOOC	0	0	1	0	0	1		0	**2**
TOTAL	**13**	**1**	**17**	**3**	**2**	**17**	**1**	**4**	**59**

[1] National is defined as organisations with national funding or specific national remit, such as medical colleges or professional associations.

Target audiences

Table 4 gives the number of genomic education activities targeted at different sectors within the workforce potentially affected by genomics. For postgraduate courses and subjects where the convener could not be interviewed, it was not clear if the target audiences were people already working in those professions or if the objective was to introduce and train them in those professions (Table B-1).

Table 4. Education activity category by target audience

Target audience	Postgraduate subject/ course	Substantive program	MOOC	Total
Clinical bioinformaticians[1]	4	7	0	**11**
Genetic professionals – clinical[2]	3	7	0	**10**
Genetic professionals – laboratory[3]	0	5	0	**5**
Medical scientists	9	7	0	**16**
Non-genetic health professionals[4]	0	17	1	**18**
Other stakeholders with an interest in genomics[5]	0	13	2	**15**
Mixed[6]	4	5	0	**9**
TOTAL[7]	**20**	**61**	**3**	

[1] There is no accredited pathway yet for clinical bioinformaticians; this category includes bioinformaticians and computer scientists working in a clinical setting.
[2] Clinical geneticists, genetic counsellors, medical specialists with genetics expertise.
[3] Genetic pathologists and elite medical scientists with advanced training in genetics and genomics.
[4] Medical specialists, non-genetic pathologists, general practitioners, nursing, midwives and allied health professionals.
[5] Health professionals or other members of the general public interested in public policy, bioethics, informed consent, legal and social issues.
[6] Genetic health professionals, non-genetic health professionals, medical scientists.
[7] Some activities had more than one target audience so totals exceed 59.

The following sub-sections summarise the programs available to different disciplines, according to content and/or convener input on target audience and actual attendees (see tables in Appendix B). The extent to which programs suit the needs of each discipline was beyond the scope of this mapping process.

Clinical bioinformaticians

There is no formally recognised discipline of clinical bioinformatician; currently professionals with bioinformatics or computer science qualifications apply bioinformatics methods and analyses to clinical genomic testing. Ten education activities were identified that either included genomic bioinformatics in the curricula, or where program convenors noted their program would be suitable for clinical bioinformaticians:

- 3 postgraduate subjects covering bioinformatics as part of genomics and genetic counselling Master degrees at University of Melbourne
- 1 postgraduate subject covering introductory bioinformatics at University of Sydney
- 2 bioinformatics training workshops offered by Bioplatforms Australia (ongoing subject to funding)
- 1 workshop on computational and data analysis skills offered by the Australian Bioinformatics and Computational Biology Society (ABCBS)
- 1 workshop on variant curation offered by Melbourne Genomics
- 3 workshops covering online bioinformatics tools, offered by The University of Queensland, University of New South Wales, and Queensland Facility of Advanced Bioinformatics.

Genetic professionals – clinical

This category includes genetic counsellors, clinical geneticists and medical specialists with training in genetics. Eight genomic education activities were identified:

- 3 Master of Genetic Counselling courses offered by University of Melbourne (relaunched in 2018), University of Sydney (on hiatus in 2018)[2] and University of Technology Sydney (due 2019)
- 1 Master of Genomics and Health, to be offered by University of Melbourne in 2018
- Human Genetics Theory, a 3rd year undergraduate subject recommended as part of Clinical Genetics Training, offered by Macquarie University
- 4–5-day practical workshop on variant analysis offered twice by the Garvan Institute of Medical Research ('Garvan') in partnership with Bioplatforms Australia for clinicians interpreting genomic reports (may be converted to online modules)
- 1.5-day workshop offered by a consortium of representatives from NSW clinical genetic services, the Garvan and the Centre for Genetics Education for genetic counsellors
- 1.5-day Annual Australian Clinical Genomics Symposium, offered by the Garvan and Centre for Genetics Education, and since also supported by Australian Genomics.
- 2, 2-day practical workshops offered by Melbourne Genomics Health Alliance ('Melbourne Genomics') for clinicians.

[2] Note, as documented at the time this research was conducted. Subsequently, the University of Sydney Master of Genetic Counselling degree has been suspended indefinitely.

Genetic professionals – laboratory

This category includes medical scientists and medically-qualified genetic pathologists with advanced training in genetics and genomics. A total of five genomic education activities were identified, all offered by the RCPA and all contributing to CPD:

- 2 sets of genomic case studies (one in collaboration with HGSA, which is not currently being updated) for early stage genetic pathologists, Faculty of Science trainees and fellows, and others working in genetic laboratories
- 3-day introductory course in medical genetics and genomics for early stage non-genetic pathology trainees, plus medical scientists
- 1-day advanced training in medical genetics and pathology at the annual Path Update meeting for non-genetic pathologists
- Genetics stream at annual Path Update meeting for non-genetic pathologists.

Medical scientists

A total of 9 postgraduate university subjects or courses were identified for medical scientists:

- Master of Diagnostic Genomics offered by Queensland University of Technology from 2018 which will form part of HGSA part 1 accreditation in Diagnostic Genomics
- 4 postgraduate subjects covering genomic theory and associated techniques are offered by the University of Western Australia
- Additional genomics subjects including both laboratory and bioinformatics aspects are offered by the University of New England, RMIT, Macquarie and Flinders Universities.

Seven substantive programs were also identified for medical scientists in training. These were usually targeted to medical scientists or bioinformaticians, offered by a combination (Bioplatforms Australia, the Garvan, RCPA, HGSA and/or ABCBS), as well as other workshops targeted at clinical audiences but attended by medical scientists, such as the workshops offered by Melbourne Genomics or the Prince of Wales Clinical School, in collaboration with the University of New South Wales.

Non-genetic health professionals

This category includes medical specialists, non-genetic pathologists and general practitioners, nursing, midwives and allied health professionals. A total of 17 substantive genomics education programs and one MOOC were identified:

- Monash University offers an online course on nutrigenomics for dieticians and was developing a nutrigenomics resource for GPs in 2017
- School of Personalised Immunology, Centre for Personalised Immunology, Australian National University, offers a 1.5-day workshop for physician advanced trainees and researchers in immunology
- RCPA offers non-genetic pathologists Introductory short courses in medical genomics (offered annually) and intermediate HGSA case studies (currently not being updated)
- Melbourne Genomics, the Garvan and Bioplatforms Australia offer a range of 1–2-day clinical genomics workshops, introducing concepts of genomics, data analysis and variant curations
- RACGP was developing an online resource for GPs in for 2017
- Victorian Comprehensive Cancer Centre offers a genomic workshop for haematologists and researchers in the field of blood disorders that may continue

- Centre for Genetics Education and the NHMRC are developing resources to assist medical specialists to understand informed genomic consent (planned for 2018), and for nursing, midwives and allied health to understand basic genetics and genomics (initially planned for 2017)
- The Royal Children's Hospital in Victoria hosts a Genetics For Trainees 2-day workshop for physicians and paediatric trainees
- RACP offers a two-part podcast for generalist physicians
- QML Pathology Service offers *ad hoc* genomic education sessions for GPs and medical specialists
- The Australian Academy of Anti-Ageing Medicine offers a workshop for complementary medicine practitioners and allied health professionals on lifestyle and ageing that incorporates genomics
- University of Melbourne offers a MOOC on epigenetics.

Mixed audiences

Many education activities attracted mixed audiences, as noted in Table 4, but two were specifically targeted at mixed audiences of genetic specialists, non-genetic specialists and medical scientists:

- Melbourne Genomics variant curation workshops
- The inaugural Annual Australian Clinical Genomics Symposium, offered by the Garvan in 2016 and now held annually in partnership with Australian Genomics.

Other stakeholders with an interest in genetics

The data revealed that some activities and resources had broader applications than initially intended by the developers, and were attended/ accessed by people beyond the target audiences, such as health professionals or members of the general public interested in public policy, bioethics, informed consent, legal and social issues. A total of 15 education activities were identified that were of interest to people not listed above:

- 3 postgraduate subjects in ethics, genomic technologies and legal aspects offered by the University of Sydney and Flinders University intended for students in bioethics, public health, medicine, science and/or law. One subject (Genetics & Public Health) could be taken by people not enrolled in a degree.
- The Garvan and Centre for Genetics Education offer a suite of curated resources on genetics and genomics for public and professional access
- Many of the substantive programs listed in Table C- 2 were also of interest to more general researchers, beyond medical scientists, bioinformaticians or genomic researchers
- Lectures offered by University of Newcastle and Convergence Science Network were attended by members of the general public
- Genomics in the Clinic: A Workshop for Health Professionals was also attended by health executives and administrators
- Both MOOCs identified, offered by the University of New South Wales and University of Melbourne, were targeted at qualified researchers and health professionals, plus interested stakeholders and the general public.

Limitations

Limitations of this approach include scope and timing. Undergraduate university subjects or courses and programs not developed in Australia were outside the scope of this research, and the audit was conducted in mid-2016, with interviews continuing into early 2017. This report therefore does not include programs conceived since 2017. As genomics is a fast-moving field, new education programs have emerged since this mapping. Google results are influenced by webpage search engine optimisation (SEO) which strategically uses keywords that mimic how a user may search for a particular topic. Additionally, having other websites link to a page, and updating the page regularly, improves SEO, which results in a higher position on the Google result list. These searches were curated in order of Google result position so education and training activities listed on pages with poor SEO may not have been included in the list of URLs for curation and therefore missed in this report.

All Google searches were performed on specific days and captured a moment in time snapshot of the results of keyword searches and do not, therefore, capture information that was or is available on the Internet before or after these searches. Additionally, some URLs returned 'Page not found' information at the time of data extraction; it is not known what content on those pages directed a URL result at the time of the keyword search.

Retrieved URLs linked to specific pages that contained the keyword used in the search; an in-depth navigation of all tabs and links on pages was not performed and therefore activities or events on other pages of the same website were not included if they did not appear in the list of URLs.

This methodology does not assess program quality or suitability for target versus actual audiences, or examine possible gaps in genomic education provision. That work is ongoing as part of Australian Genomics Workforce Education research, by comparing and contrasting Internet search results and interview data.

Future Directions

Improve information available online about relevant genomic education

This mapping exercise identified 59 genomic education activities produced and/or available in Australia in 2016 via review of relevant professional organisation and college websites and newsletters and systematic Google searches. Many programs did not have an online presence and were only identified through interviews or professional organisation membership emails or newsletters. Details of some programs were also only gained through convenor interviews. It is likely that potential audiences are therefore reliant on being notified of activities and that some activities may miss potential participants due to a lack of Internet presence. Further Australian Genomics Workforce Education research will explore the needs of health professionals, including identifying relevant education opportunities in genomics.

Consider multidisciplinary audiences when designing genomic education activities

Programs were mainly aimed at clinical and laboratory professionals but convenors noted that attendees often extended beyond the target audience and were often multidisciplinary. While programs are best designed to meet the needs of the target audience, ensuring programs acknowledge upfront that a varied and wide audience may be interested to participate will promote and provide access to a range of professions.

Establish an evidence base to guide appropriate, high quality genomics education activities

These results provide a baseline for assessing change in genomics education over time, especially after the Australian government's new National Health Genomics Policy Framework launches in 2018.[3]

There are currently no well-established quality metrics in genomics education and no structures to assess health professional needs and program suitability in a systematic, ongoing way. The mapping methodology used here allows future rigorous data collection and reporting, noting direct contact with conveners is necessary to supplement online information. Further Australian Genomics Workforce Education research will also develop a generic program logic and evaluation framework for genomics education activities and resources to help establish these metrics and evidence base.

[3] Australian Government Department of Health. (2017). *National Health Genomics Policy Framework 2018-2021*. Retrieved from Canberra, ACT: http://www.health.gov.au/internet/main/publishing.nsf/Content/national-health-genomics-policy-framework-2018-2021

Appendix A: Detailed Methods

Research governance and design

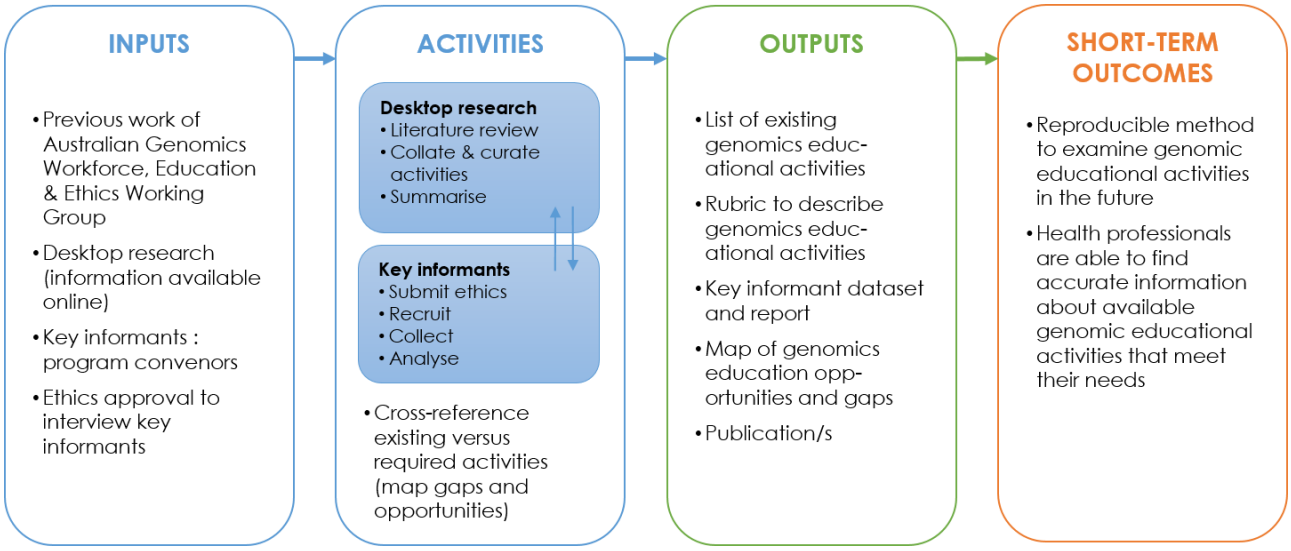
The project was overseen by a Working Group comprised of professionals with expertise in genomics education and bioethics. Working Group members include:

- A/Prof Clara Gaff, Co-lead, Genomic Workforce Education (Executive Director, Melbourne Genomics Health Alliance)
- Prof Sylvia Metcalfe, Co-lead, Genomic Workforce Education (Group Leader, Genetics Education and Health Research, Murdoch Children's Research Institute and Department of Paediatrics, The University of Melbourne)
- A/Prof Ainsley Newson, Co-Lead, Genomic Ethics (Centre for Values, Ethics and Law in Medicine, University of Sydney)
- Ms Kate Dunlop (Director, Centre for Genetics Education, NSW Health)
- Ms Bronwyn Terrill (Manager, Education and Communication, Kinghorn Centre for Clinical Genomics (KCCG), Garvan Institute of Medical Research)
- Dr Debra Graves (CEO, Royal College of Pathologists of Australasia)

The project received ethics approval from The University of Melbourne (HREC Number: 1646785.1). Three Project Officers were selected to conduct the research based on their knowledge and experience in genetics and genomics education.

Working group discussions at the project outset led to the development of a program logic model for genomic education activity mapping in Australia, which was updated over time in response to shifts in methodological design during planning and data collection phases of the project. The final model is shown in Figure A- 1.

Figure A- 1. Program logic for genomic education activity mapping in Australia



The methodological approach outlined in Figure A- 1 was agreed by the Working Group, and involved a combination of desktop research (medical college and professional organisation website and/or newsletter search, Google keyword search) and key informant interviews to produce a list of existing genomic education activities and a rubric to describe them.

Website and internet searches

Medical colleges website searches

The Australian Genomics Workforce, Education & Ethics Working Group agreed that the medical colleges to target first were Royal College of Pathologists of Australasia (RCPA), Royal Australasian College of Physicians (RACP), Royal Australian College of General Practitioners

(RACGP), and Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG).

Each website was navigated manually by pressing sequentially on each of the available tabs to access the content, which enabled the project officers to gain an understanding of the overall curriculum pathway of each college, including the training and Continuing Professional Development (CPD) requirements and to assess the level of genomics content present on each website. Some content was password-protected for members-only access.

In addition, each website had a search function into which the term 'genom' was entered to cover "genome", "genomic" and "genomics" and resulting retrieved search list was examined by project officers for the presence of formal education activities that may be of interest to Australian Genomics Workforce Education research.

Human Genetics Society of Australasia website search

Similarly, the Human Genetics Society of Australasia (HGSA) website was reviewed for the presence of genomic education activities, and for possible key informants based on their roles on education committees or contribution to genomic education activities.

The HGSA website was first reviewed by manual navigation through the available tabs and then specifically searched for the terms 'genom*', 'MOPS', in caps, 'WES', 'exome', 'precision' and 'personal'. Sections of the website for the Special Interest Groups (SIGs) were additionally reviewed using member logins: Australasian Society of Genetic Counsellors (ASGC), Australasian Association of Clinical Geneticists (AACG) and Australasian Society of Diagnostic Genomics (ASDG). Most educational content was password-protected for members-only access, at both HGSA and SIG-level.

The HGSA secretariat provided 54 e-newsletters distributed to members between July 2013 and September 2016. Newsletters were searched for genomic education activities using the terms 'genom*', 'MOPS', in caps, 'WES' 'exome', 'precision' and 'personal'.

Google search

An internet search was performed on 3 and 6 June and 4 July 2016 using the Google Chrome browser and results were filtered to Australian sites only using the Google site-limiting tool. The following 17 search terms were entered sequentially:

"genomic workshop";
"genomic seminar";
"genomic webinar";
"genomic course";
"genomic training";
"personalised medicine";
"precision medicine"
"genomic sequencing";
"interpreting genomic result";
"genomic medicine";
"genomic diagnosis";
"understanding genomics";
"genomic";
"genomic resource";
"genomic mooc";
"genomic animation";
"genomic ebook"

The first 60 Google results retrieved for each search were exported to Excel in order of search retrieval, so data were reflective of site content on those dates. Search results were combined into one table and duplicates were removed automatically based on URL field. Also removed were any non-human or non-clinical genomic activity results. Results were then exported to an Access database and curated against inclusion/exclusion criteria, as detailed in Table A- 1.

Where possible, the following data were captured for each activity: website URL, type of activity (*e.g.,* workshop, ebook) organisation(s) hosting the education activity, year of delivery (first delivery, latest delivery), audience and a brief summary of relevant content.

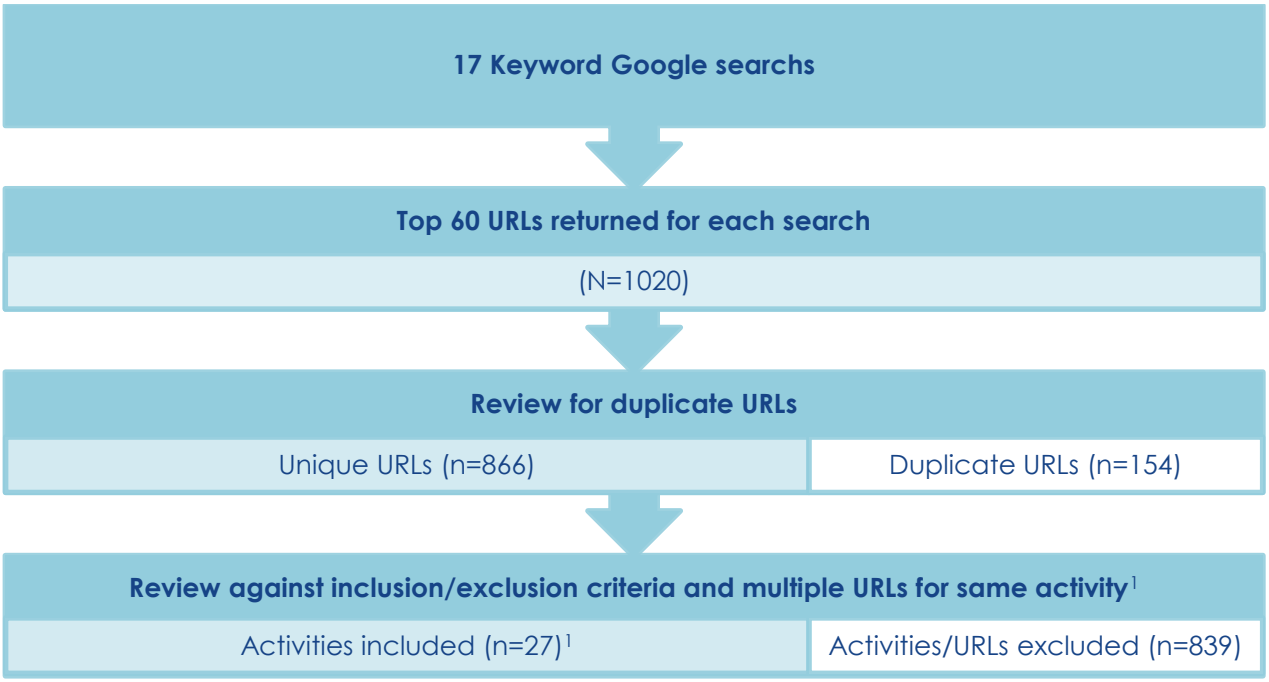
Table A- 1. Inclusion and exclusion criteria for Google search results of genomic education activities

Inclusion criteria	Exclusion criteria

• Developed, hosted or based in Australia
• Produced since 2011
• Activities advertised on the page returned by the URL, not through navigating further through a website
• Content related to
  ○ genomics, i.e., the study of complete sets of DNA including structure, function, evolution, mapping, and associated technologies
  ○ clinical, human genomics
• Ongoing or more permanent programs of genomic education, likely to be retained or built upon in the foreseeable future
• Postgraduate university subjects that could be completed either within a degree or outside enrolment in a full program, such as a subject within a Master of Biotechnology
• Substantive (ongoing) programs suitable for CPD for health professionals and genomic specialists
• MOOCs, if produced in Australia
• Training in use of free open-source bioinformatics software
	• Non-human or non-clinical genomic activity results
	• Content related to genetics, i.e., the study of heredity and the effect of single gene polymorphism on function
	• Undergraduate subjects or subjects only available if enrolled in university degree programs[1]
	• Scientific conferences with a research focus rather than educational
	• Webpages providing information about genomics rather than an education or training event/program, including university department or medical research institute pages describing research activities
	• News articles, media releases, annual reports
	• Journal articles, PhD theses, grant proposals, patent applications
	• eBooks and library catalogue excerpts
	• International or web-based activities hosted by an international group (even if accessible in Australia)
	• Webpages with access or information restricted by a member-only log-in
	• Service provision webpages, e.g., diagnostic laboratory test information or bioinformatics services
	• Education or training activities provided by private companies to customers of their commercial product
	• Advertisements for job vacancies or individual researcher profile pages
	• Once-off events or regular 'in house' events, i.e.,
	  ○ Multidisciplinary team meetings (MDTs)
	  ○ Grand rounds, journal clubs, seminar series
	  ○ Other 'business as usual' on-the-job education or training
	• Broken links or URL errors

[1] University subjects that were separately identified through interviews are included in results but the Internet search methodology was not specifically designed to comprehensively audit all university subjects and/or courses available in Australia.

Figure A- 2. Systematic review process to identify activities through Google search



[1] Final results indicate numbers of activities identified, as opposed to number of URLs reviewed, as activities could have more than one related URL.

Working Group input and genomic education activities shortlist

Project officers first conducted interviews with Australian Genomics Workforce, Education & Ethics Working Group members as a means to identify further genomics education programs. Interviews were performed by phone during July 2016 (n=4) and face to face (n=2). Education activities mentioned during the interview, as well as recommendations for key informants were noted and Working Group members were asked to inform project officers of any new education activities they become aware of on an ongoing basis.

The decision to interview Working Group members was also seen as an opportunity to trial the draft interview schedule submitted and approved by Melbourne University ethics.

As a result of the desktop research, and on instruction by the Working Group, a preliminary list of education activities was constructed. Table A- 2 shows how many activities were identified via one or more of the methods utilised in this study: medical college websites or HGSA website/newsletter; Working Group input; and/or Google keyword search.

Table A- 2. Original means by which education activity identified

How many activities identified using each method	n
Medical college or HGSA website/newsletter	2
Working Group input	23
Google search	23
[Medical college or HGSA website/newsletter] + Working Group input	6
[Medical college or HGSA website/newsletter] + Google search	0
[Medical college or HGSA website/newsletter] + Working Group input + Google search	1
Working Group input + Google search	3
TOTAL	**59**

Education activities that were identified as 'business as usual' or standard professional development activities were excluded from the list, *e.g.,* participation in local journal clubs, grand rounds, multidisciplinary team meetings or one-off lectures. Education activities that remained in scope were postgraduate university subjects, MOOCs and substantive ongoing programs (*e.g.,* workshops, resources, modules) that would likely earn formal CPD recognition from the various health professional accreditation bodies.

Education activities deemed suitable for further investigation were further reviewed and, where possible, data matching the following case fields were collected from either university handbooks, online sources or via Working Group input [meeting requirement of program logic- see Figure A- 1, Output 2.

Table A- 3. Rubric to describe genomic education activities

Case field
Name
Subject code (where applicable)
Host organisation
Brief summary of content
Recommended prior knowledge or skills
Delivery method
Evaluation
Audience (intended + actual)
Certification
Status

Key informant selection and interviews

Convenors of each identified educational activity in scope were approached by email inviting them for a semi-structured interview using a standard contact letter. Those who responded were sent a plain language statement and consent form, and an interview was scheduled at their convenience either by phone or face-to-face. Convenors were given the opportunity to give written or verbal consent at the beginning of each interview. Each interview was digitally recorded and transcribed verbatim using Microsoft Word. The resulting audio and Word files were transferred to a secure server at Murdoch Children's Research Institute for storage. Immediately after each interview, a record was created in REDCap, a secure online research database hosted by MCRI, to record the details of the interviewee and interview, including consent information and transcribing status.

The first part of each interview involved collection of basic information about the participant, including formal qualifications and experience leading to them becoming the convenor of the particular activity. The second part of the interview involved asking the participant to confirm the various aspects to the activity, such as content, delivery method, assessment structure, whether the workshop was evaluated, and whether there was an intention to re-run the activity. Information gained during the interview was then used to supplement that collected by the desktop research and a list of education activities resulted. In addition to the list, the history of development of each major education program including details about the uptake of the activity and likely future directions was constructed to provide context and highlight major strengths.

Each convenor who was interviewed was then re-contacted after data analysis and asked to review results relevant to them to ensure the accuracy of the resulting activities list.

Appendix B: Methods to Identify and Verify Education Activities

Appendix B provides data about the information sources for all activities identified. Detailed information about the three types of genomics education activities identified are then provided in Appendix C.

Table B- 1. Details of how postgraduate courses and subjects were identified and verified[1]

Name	Host organisation	Location	Identified via			Curriculum/ content verified via
			Working group	Google	College/ HGSA	
Advanced Genomics Techniques	Uni. Western Australia	WA	✓			Website (no interview response)
Advanced Studies in Genetics & Genomics	Uni. Western Australia	WA	✓			Website (no interview response)
DNA to Genome	Flinders University	SA	✓			Website (no interview response)
Ethics & Biotechnology	Uni. Sydney	NSW	✓			Interview
Genetics & Public Health[2]	Uni. Sydney	NSW	✓			Interview
Human Genetics Theory	Macquarie University	NSW	✓			Interview
Introduction to Bioinformatics	Uni. Sydney	NSW	✓			Website (no interview response)
Legal, Ethical & Social Aspects of Bioscience	Flinders University	SA	✓			Website (no interview response)
Master of Diagnostic Genomics (Grad Dip, Grad Cert)	QLD Uni. Technology	QLD	✓		HGSA	Interview
Master of Genetic Counselling	Uni. Melbourne	VIC	✓			Interview
Master of Genetic Counselling	Uni. Sydney	NSW	✓		HGSA	Interview
Master of Genetic Counselling	Uni. Technology Sydney	NSW	✓			(No website or convener at time of research)
Master of Genomics & Health (Grad Dip, Grad Cert)	Uni. Melbourne	VIC	✓			Interview
Bioinformatics & Data Analysis for Genomics	Uni. Western Australia	WA		[3]		Interview
Computational Genomics	Uni. Melbourne	VIC		[3]		Interview
Elements of Bioinformatics	Uni. Melbourne	VIC		[3]		Interview
Genomic Analysis & Bioinformatics	Uni. New England	NSW		[3]		Interview
Genomics & Bioinformatics	Uni. Melbourne	VIC		[3]		Website (no interview response)
Molecular Genetics & Diagnostics	Royal Melbourne Institute of Technology	VIC		[3]		Interview
Objectives & Applications of Genomics	Uni. Western Australia	WA		[3]		Interview

[1] This list is not intended to be an exhaustive audit of all university subjects or courses as those activities were excluded from Internet search results as it could not be verified if subjects and courses were available to people not enrolled as students. These activities are included in this table as they were all referenced in Working Group interviews.

[2] This subject was the only one clearly marked as being 'non-award study' on the university website, i.e., could be taken as a single unit without enrolling in a degree.

[3] These subjects and courses were cited by convenor/s of other education activities but did not meet the inclusion criteria for Google search results.

Table B- 2. Details of how substantive programs and ad hoc resources were identified and verified

Name	Host organisation	Location	Identified via			Curriculum/ content verified via
			Working group	Google	College/ HGSA	
Annual Australian Clinical Genomics Symposium	Garvan, now in partnership with Australian Genomics	National	✓			Interviews (2)
Applying Emerging Genomic Data to Care of Patients with Blood Disorders	Victorian Comprehensive Cancer Centre	VIC		✓		Website, Interview
Bioinformatics training (various)	Bioplatforms Australia	National	✓	✓	✓	Website, Interview
Cancer Genomics Workshop	Bioplatforms Australia	National		✓		Website, Interview
Clinical Genomic Data Analysis: A Practical Course	Garvan in partnership with Bioplatforms Australia	NSW	✓	✓		Website, Interview
Convergence Science Symposium	Convergence Science Network	VIC		✓		Website
DNA to Genome	Flinders University	SA	✓			Website (no interview response)
Food & Our Genome	Monash University	VIC			RACGP	Interview
Genetics for trainees	RACP, RCH Melbourne	Vic		✓		Website
Genetics & Genomics in Family Medicine	RACGP	National	✓			Interview
Genetics & Genomics Resources	Centre for Genetics Education	NSW	✓			Interview
Genetics & Genomics Resources (PDFs) for Clinicians & Researchers	NH&MRC	National		✓		Website
Genetics & Genomics Update for Nursing, Midwifery & Allied Health	Centre for Genetics Education	NSW	✓			Interview
Genomic Bioinformatics Workshop: Update in Medical Genetics & Genetic Pathology[1]	RCPA; Australian Assoc. of Clinical Biochemists (AACB); HGSA	NSW		✓		Website
Genomic Case Studies	RCPA	National	✓		RCPA	Interviews (2)
Genomic Counselling for Genetic Counsellors	NSW Health Clinical Genetics Services, Garvan, Centre Genetics Education	NSW	✓			Interview
Genomic Data Analysis Roadshow	Australian Bioinformatics and Computational Biology Society (ABCBS); International Society for Computational Biology (ISCB)	National		✓		Website
Genomics for the Generalist	RACP	National	✓			Interview
Genomics in Newborn Screening (NBS): Potential Targets & Benefits: 50th Anniversary NBS Symposium	Victorian Clinical Genetics Services (VCGS)	VIC		✓		Website
Genomics Workshop	HGSA, 2016 Annual Scientific Meeting	TAS		✓		Website, Interview
Introduction to Nutritional Genomics	Monash University	VIC		✓		Website, Interview
Introductory Human Genome Bioinformatics workshop	Uni. New South Wales	NSW		✓		Website, Interview
Introductory Short Course in Medical Genetics & Genomics (3-day)	RCPA	National	✓	✓		Website, Interviews (2)
Learn About (Clinical) Genomics, Genetics PINTEREST page, publication database	Garvan	NSW	✓			Interview

Name	Host organisation	Location	Identified via			Curriculum/ content verified via
			Working group	Google	College/ HGSA	
Lifestyle Interventions & a Personalised Medicine Approach to Healthy Ageing	The Australian Academy of Anti-ageing Medicine	VIC		✓		Website
Molecular Karyotyping: New Advances in Constitution-al & Prenatal Diagnostic Testing	QML Pathology Service	National			RACGP	Interview
Pathology Update: Genetics Stream	RCPA	National	✓		RCPA	Interviews (4)
Practical Genomics: A 2-day Workshop for Genomics in the Clinic	Melbourne Genomics	VIC	✓	✓		Website, Interviews (3)
Precision Medicine: Public Lecture	Uni. Newcastle	NSW		✓		Website
RCPA/ HGSA Case Studies	RCPA, HGSA	National	✓		RCPA, HGSA	Interviews (2)
School of Personalised Immunology	Centre for Personalised Immunology, Australian National University	ACT		✓		Website, Interview
Short Course in Medical Genetics & Genetic Pathology (1-day)[1]	RCPA; HGSA	National	✓		RCPA	Interviews (3)
Sydney Genomics Collaborative Scientific Symposium	KCCG; Garvan; NSW Health	NSW		✓		Website
Understanding Informed Genomic Consent	Centre for Genetics Education	NSW	✓			Interview
Variant Curation Workshop	Melbourne Genomics	VIC	✓			Interview
Whole Genome Sequencing Data Analysis workshop	Queensland Facility for Advanced Bioinformatics	QLD		✓		Website
Winter School in Mathematical & Computational Biology	Uni. Queensland	QLD		✓		Website

[1] These are two separate workshops/courses.

Table B- 3. Details of how MOOCs were identified and verified

Name	Host organisation	Location	Identified via			Curriculum/ content verified via
			Working group	Google	College/ HGSA	
Myths & Realities of Personalised Medicine: The Genetic Revolution	Uni. New South Wales	NSW	✓			Interview
Epigenetic Control of Gene Expression	Uni. Melbourne	VIC	✓			Interview

Table B- 4. Details of Google keyword search outcomes for education and training activities and resources related to genomic medicine

Name	Type	Host organisation	Location	URL	Search term	Search position
Applying Emerging Genomic Data to Care of Patients with Blood Cancers	Workshop	Walter and Eliza Hall Institute, VCCC	VIC	www.victorianccc.org.au/assets/Haem-Workshop-Program.pdf	interpreting genomic result	16
				www.victorianccc.org.au/events/applying-emerging-genomic-data-to-care-of-patients-with-blood-cancers/	genomic workshop genomic	8 47
Cancer Genomics Workshop	Workshop	Bioplatforms Australia; Victorian Life Science Computer Initiative (now Melbourne Bioinformatics)	VIC	www.bioplatforms.com/cancer-genome-8-feb-16/	genomic workshop interpreting genomic result	5 49
Clinical Genomic Data Analysis: A Practical Course	Workshop	Garvan; Bioplatforms Australia	NSW	http://www.bioplatforms.com/clinical_genomics_2015/	genomic workshop understanding genomics	6 32
				http://www.bioplatforms.com/wp-content/uploads/CGDA_Course_outline_231015.pdf	genomic course	16
				http://australianbioinformatics.net/past-events/2015/12/14/clinical-genomics-data-analysis-a-practical-course-garvan-in.html	genomic course	25
Convergence Science Symposium	Symposium	Convergence Science Network	VIC	www.convergencesciencenetwork.org.au/convergence-2015.html	precision medicine genomic medicine	32 56
Genetics & Genomics Resources for Clinicians & Researchers	Information sheets	NH&MRC	National	www.nhmrc.gov.au/health-topics/genetics-genomics-and-human-health/genetics-and-genomics-resources-clinicians-and-rese	interpreting genomic result	53
Genetics For Trainees	Short course	Royal Children's Hospital, Melbourne	VIC	www.geneticsfortrainees.com.au/#!resume/c13dn	genomic course	56
Genomic Bioinformatics Workshop: Update in Medical Genetics & Genetic Pathology	Short course (3-days)	RCPA, AACB, HGSA	National	www.rcpa.edu.au/Fellows/Specialist-Training-Program/Courses	genomic workshop	41
				www.aacb.asn.au/documents/item/678	genomic course genomic diagnosis	26 59
Genomic Data Analysis Roadshow	Annual symposium	ABCBS; ISCB	National	https://combine.org.au/agta_roadshow/	genomic workshop	23
Genomics in Newborn Screening (NBS): Potential Targets & Benefits; 50th Anniversary NBS Symposium	Symposium	VCGS	VIC	www.mcri.edu.au/sites/default/files/media/documents/nbs_sue_white.pdf	genomic sequencing	53
Genomics Workshop	Workshop	HGSA	TAS	www.hgsa.org.au/about/HGSA2016-genomics-workshop	genomic workshop interpreting genomic result genomic diagnosis	0 1 6
Introduction to Nutritional Genomics	Short course	Monash Uni.	VIC	www.med.monash.edu.au/base/short-courses/nutritional-genomics.html	genomic course	1

Name	Type	Host organisation	Location	URL	Search term	Search position
Introductory Human Genome Bioinformatics Workshop	Workshop	Uni. New South Wales; Prince of Wales Clinical School	NSW	https://powcs.med.unsw.edu.au/bioinformatics_workshop	genomic workshop	2
Lifestyle Interventions & A Personalised Medicine Approach to Healthy Ageing	Workshop	Aust. Acad. Anti-Ageing Medicine (AAAM); Aust. Soc. Lifestyle Medicine (ASL); Aust. Traditional Med. Soc. (ATMS); Aust. Natural Therapists Assoc. (ANTA); Complementary Med. Assoc.	VIC	www.a5m.net/events/event/2016-pre-conference-workshop-1-lifestyle-interventions-and-a-personalised-medicine-approach-to-healthy-ageing	personalised medicine	36
Precision Medicine: Public Lecture	Seminar	Uni. Newcastle	NSW	www.newcastle.edu.au/events/faculty-of-health-and-medicine/public-lecture-precision-medicine	precision medicine	1
School of Personalised Immunology	Workshop	Centre for Personalised Immunology, Australian National University	ACT	https://cpi.org.au/?q=inaugural-school-of-personalised-immunology-educates	genomic medicine	22
Short Course in Medical Genetics & Genetic Pathology	Workshop (1-day)	RCPA, AACB, HGSA	NSW	http://australianbioinformatics.net/past-events/2013/9/28/the-genomic-bioinformatics-workshop-sydney.html	genomic workshop	18
Sydney Genomics Collaborative Scientific Symposium	Symposium	KCCG; Garvan; NSW Health	NSW	https://wordvine.sydney.edu.au/files/1446/10487/	genomic webinar	31
Whole Genome Sequencing Data Analysis	Workshop	Queensland Facility for Advanced Bioinformatics	QLD	www.qfab.org/whole-genome-sequencing-data-analysis/ (now superseded by www.qfab.org/training)	genome sequencing	24
Winter School in Mathematical and Computational Biology	Short course	Uni. Queensland	QLD	http://bioinformatics.org.au/ws15/program/	genomic workshop genomic course	43 58

Appendix C: Content of Genomic Education Activities

Appendix C provides data detailed information about the three types of genomics education activities identified: postgraduate courses and subjects, substantive programs and MOOCs.

Table C- 1. Details of postgraduate courses and subjects sorted by title, including organisation, including location, content, delivery and audience

Name	Code	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certification	Status
Advanced Genomics Techniques	GENE5001	Uni. Western Australia	WA	Genomics techniques	U'grad qualification	One semester, F2F lectures + tutorial	Unknown	Medical scientists in training	Unknown	Contributes to Masters	Unknown
Advanced Studies in Genetics & Genomics	GENE4001	Uni. Western Australia	WA	Advanced & population genomics, cellular biology	U'grad qualification	F2F lectures + presentations	Unknown	Medical scientists in training	Unknown	Contributes to Masters	Unknown
Bio-informatics & Data Analysis for Genomics	SCIE4002	Uni. Western Australia	WA	Computational genomics	U'grad qualification	One semester, F2F lectures, tutorials + group presentation	Unknown	Trainee biotech scientists (med., agri-cultural, env-ironmental)	As intended	Contributes to Masters	Ongoing
Compu-tational Genomics	COMP90016	Uni. Melbourne	VIC	Computational approaches & algorithms for genomic analysis	U'grad prog-ramming	One semester, F2F lectures + prac.s		Bioinf. in training	⅓ science, ⅓ comp-uting, ⅓ bioinf.	Contributes to Masters	Ongoing
DNA to Genome	BIOL8004	Flinders University	SA	Review concepts of genes, genomics, molecular biology whole genome sequencing	2nd yr u'grad molecular biology	F2F lectures + prac.s + computer lab	Unknown	Medical scientists in training	Unknown	Contributes to Masters	Unknown
Elements of Bio-informatics	BINF90002	Uni. Melbourne	VIC	Overview main bioinf. areas, presented by experts in fields	U'grad	One semester, F2F lectures + prac.s		Bioinf. in training	⅓ biosci., ⅓ comp-uting, ⅓ maths/ stats	Contributes to Masters	Ongoing
Ethics & Biotech-nology	BETH5201	Uni. Sydney	NSW	Intro to ethical, social & legal issues associated with various biotechnologies	U'grad qualification	One semester, F2F 1-day workshop + online	Unknown	Varied	Master of Bioethics or Master of Medicine students	Contributes to Masters	Ongoing
Genetics & Public Health	PUBH5116	Uni. Sydney	NSW	Basic introduction to genetics, & more detailed case studies showing how genetics is applied in public health practice, incl. ELSI	U'grad qualification	F2F 2.5-day workshop + online preliminary lectures	Unknown	Varied. Mostly p'grad students & others working in health	Clinical epidemiol ogy & Master of public health students	Contributes to Master	Ongoing

Name	Code	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certification	Status
Genomic Analysis & Bioinformat-ics	GENE552	Uni. New England	NSW	Review concepts & methods to work with & analyse genomic data	U'grad qualification	Mainly online + prac.s	Unknown	Biomedical scientists in training	Science, comp-uting, biomed, animal breeding	Contributes to Masters	Ongoing
Genomics & Bio-informatics	BTCH90009	Uni. Melbourne	VIC	Genomic technologies to investigate genome & protein structure	U'grad genomics or bioinf.	One semester, F2F lectures + prac.s		Bioinf. in training	Unknown	Contributes to Masters	Ongoing
Human Genetics Theory	BIOL345	Macquarie University	NSW	3rd yr subject. Pedigrees, population studies, in-breeding, cytogenetics, genome organisation, genetic disease, human genetics technologies & research methods	Knowledge of genetics & genomics	One semester, F2F lectures + tutorials	Unknown	Scientists in training, trainee clinical genetic fellows	90% as intended + 10% non-genetic trainee clinicians	Contributes to science degree & clinical genetics fellowship training	Ongoing, new conven-or 2017
Introduction to Bio-informatics	COMP5456	Uni. Sydney	NSW	Essentials of bioinf. data gathering, manipulation, mining & storage	U'grad prog-ramming + molecular biology	One semester, F2F lectures + prac.s		Bioinf. in training	Unknown	Contributes to Masters	Ongoing
Legal, Ethical & Social Aspects of Bioscience	BTEC8003	Flinders University	SA	Impact of new biotech-nologies on law, ethics, society & environment	U'grad qualification	One semester, F2F lectures + tutorials	Unknown	Law/science students	Unknown	Unknown	Unknown
Master of Diagnostic Genomics (Grad. Dip., Grad. Cert.)	Un-known	QLD Uni. Technology	QLD	Core: cellular & molecular biology, human genetics, disease pathogenesis, diagnostic genetics, genetic technologies, lab. management compliance & quality control, genomics analysis, ELSI, molecular, biochemical & cytog-enomics. Electives: cancer genomics, genetic epidemiology, comp. bio, pharmacogenomics	U'grad qualification	Mostly online with some F2F & other flexible learning	Unknown	Medical scientists currently working in a laboratory	Unknown	Will contribute to MHGSA (Diagnostic Genomics) Part 1 accredita-tion + case studies	Due 2018
Master of Genetic Counselling	Un-known	Uni. Melbourne	VIC	Three subjects covering advanced genomics & variant curation	U'grad qualification in bio or other disci-pline + 2 yr	Blended F2F + online	Unknown	Genetic counsellors in training	–	Masters	Reviewe d 2017; due 2018

Name	Code	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certification	Status
					relevant work experience						
Master of Genetic Counselling	NA	Uni. Sydney	NSW	Subjects covering advanced genomics & variant curation	U'grad qualification	One semester, F2F lectures + tutorials	Unknown	Genetic counsellors in training	50% biosci., 50% counsel-ling	Masters	Ongoing
Master of Genetic Counselling	Un-known	Uni. Technology Sydney	NSW	Unknown	Unknown	Unknown	Unknown	Genetic counsellors in training	–	Masters	Due 2019
Master of Genomics & Health (Grad Dip, Grad Cert)	Un-known	Uni. Melbourne	VIC	Several subjects covering advanced genomics & variant curation	U'grad qualification in bio or other disci-pline + 2 yr relevant work experience	tbc	Unknown, to include med.sci.	Unknown	–	Masters	Due 2018
Molecular Genetics & Diagnostics	ONPS2094	RMIT	VIC	Molecular genetics & diagnostics, focus on human genetics & new technologies	U'grad qualification	F2F lectures + prac.s + independent study	Unknown	Medical scientists in training	Unknown	Contributes to Masters	Ongoing
Objectives & Applications of Genomics	SCIE4001	Uni. Western Australia	WA	Genomics, epigenomics, transcriptomics, proteomics & metabolomics	U'grad qualification	One semester, F2F intensive + online	Unknown	Medical scientists in training	As intended	Contributes to Masters	Ongoing

Table C- 2. Details of substantive programs and ad hoc resources sorted by title, including host, location, content, delivery and audience

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
Annual Australian Clinical Genomics Symposium	Garvan, now in partnership with Australian Genomics	National	Developments in genomics, best practice & challenges implementing clinical genomics. First run Nov 2016	Health professionals & stake-holders with interest in genomics	F2F 1.5-day + lectures, case studies, report interpretation	Post-symposium survey re satisfaction	Clin.gen., gen.couns., med.sci., non-genetic health prof.s, other stake-holders	As intended	Contributes to CPD (optional)	Ongoing annual, nation-al
Applying Emerging Genomic Data to Care of Patients	Victorian Compre-hensive Cancer Centre; WEHI	VIC	Workshop on molecular literacy in haematologic malignancies. Genomic technologies, conveying genomic results to colleagues & patients,	Knowledge of genomics (scientists) or haematology (clinicians)	F2F 1-day workshop, lectures + panel session	Post-workshop survey re satisfaction	Haematology consultants, fellows & trainees, nursing & allied health,	As intended including jointly trained pathologists, nurses,	Certificate of attend-ance can contribute to CPD	Poss. on-going due 2017 or 2018 re needs

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
with Blood Disorders			malignant haematologic genetic aberrations. Run March 2016				sci. interested in blood cancers	researchers, scientists		assess-ment
Bio-informatics training (various)	Bio-platforms Australia	National	Next generation sequencing analysis, variant detection, de novo assembly, RNA-Seq, ChIP-Seq. Began in 2014	Range (From no prior knowledge to basic programming skills	F2F 1-3 day workshop	Post-workshop survey re satisfaction. Long-term survey (poor response)	Researchers	As intended + med.sci, PhDs, ~10% clinicians	None	Ongoing subject to funding
Cancer Genomics Workshop	Bio-platforms Australia, Melbourne Bioinform-atics	VIC	Next generation sequencing analysis, experimental design, variant interpretation, annotation and visualisation of cancer genome data. Intro to cancer genomics analytical pipelines for single nucleotide variations (SNV), copy number variations (CNV) and structural variations (SV). Run 2015	U'grad prog-ramming + general cancer genomics	F2F 3-day workshop	Post-workshop survey re satisfaction. Long-term survey	Researchers, bioinf.	As intended + med.sci, clinician PhDs, ~10% clinicians	None	Ongoing subject to funding User-pays; $495
Clinical Genomic Data Analysis: A Practical Course	Garvan in partnership with Bio-platforms Australia	NSW	Genome structure, variant analysis incl. quality metrics, filtering, consent, examine clinical genomic data; understand processes underpinning clinical genomic data analysis; hands-on experience identifying variants and impact. Run 2015, 2016	Qualification in genetics/ genomics	F2F 4–5-day workshop + prac. + panel	Post-workshop survey re satisfaction (will publish)	Clin.gen., gen.couns., med.sci., gen.path, lab.sci, non-genetic health prof.s	Mostly clin.gen. + med.sci., path, non-genetic health prof.s, gen.couns.	Contributes to CPD	Unknown; possibly online User pays; $700+GST
Converg-ence Science Symposium	Converg-ence Science Network	VIC	Conversation about promises of Precision Health & Medicine & challenges in implementing them for improved health outcomes	Unknown	F2F	Unknown	Researchers, students, non-genetic health prof.s, health policy, hospital admin, patient advocates	Unknown	Unknown	Unknown

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
Food & Our Genome	Monash University	VIC	Basic genetics & nutritional genomics, clinical application & personalised nutrition	None or very basic know-ledge of genetics & genomics	Online, 40 hr. Videos + case studies	Currently evaluated via qualitative research project	General practitioners	tbc	Contributes to CPD	In develop-ment
Genetics & Genomics in Family Medicine	RACGP	National	Prenatal diagnosis, personalised medicine, genomic technologies in clinical practice, cancer genomics, pharmaco-genomics	Basic knowledge of genetics & genomics	Searchable online resource + educational activities tbc	tbc	General practitioners registered with RACGP & Australian College of Rural & Remote Medicine	tbc	Activities may contribute to CPD (tbc)	Due Nov 2017
Genetics & Genomics Resources	Centre for Genetics Education	NSW	Basic genetics & genomics, specific genetic conditions, impact of genetics in society, genetic & genomic testing. Reviewed 2015; due 2017	None	Online factsheets, brochures, resource, services and support links	None	General public, health pro-fessionals seeing genetic conditions or concerns	As intended	None	Ongoing
Genetics & Genomics Resources for Clinicians & Researchers	NH&MRC	National	Information and advice on genetics or genomics and human health	Unknown	Online factsheets	Unknown	Health pro-fessionals, researchers	Unknown	Unknown	Ongoing Free access
Genetics & Genomics Update for Nursing, Midwifery & Allied Health	Centre for Genetics Education	NSW	In development	None or very basic know-ledge of genetics & genomics	Online	Post-module survey; completion rates	Nurses, midwives & allied health working for NSW Health	tbc	Will contribute to CPD	Due July 2017
Genetics For Trainees	Royal Children's Hospital	VIC	Basic genetics & genomics, specific genetic conditions, testing technologies	Medical qualification with specialised training	F2F	Unknown	Physicians and paediatric trainees	Unknown	Unknown	Ongoing Cost not stated
Genomic Bioinformat-ics Workshop: Update in Medical Genetics & Genetic Pathology	RCPA; HGSA; AACB	National	Gen.path, contemporary and emerging training/ CPD requirements. 2011, 2013, 2013	Unknown	F2F 3- or 4-day workshop	Unknown	Path., med.sci involved in lab services	Unknown	Will contribute to Fellowship and CPD	User pays: $600–1,100

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
Genomic Case Studies	RCPA	National	Genomic case studies	Genetics & genomics knowledge	Online	Unknown	Non-gen.path. registrars, gen.path, Faculty of Science fellows & trainees	As intended + those working in genetic laboratories	Contributes to CPD	Ongoing
Genomic Counselling for Genetic Counsellors	NSW Health Clinical Genetics Services in partnership with Garvan & Centre for Genetics Education	NSW	Next generation sequencing, bioinf., variant interpretation, role of genetic counsellor in genomics. Run 2015; possibly run again by Centre for Genetics Education	Qualifications in genetics/ genomics	F2F 1.5-day workshop + prac. + panel	Post-workshop survey re knowledge & satisfaction	NSW gen. couns.	As intended	Contributes to CPD for genetic counsellors (MOPs)	Un-known; poss due 2017
Genomic Data Analysis Roadshow	ABCBS; ISCB	National	Essential computational and data analysis skills. Run 2015	Unknown	F2F	Unknown	Bioinf., sci., researchers	Unknown	Unknown	Ongoing
Genomics for the Generalist	RACP	National	Genomic technologies, prenatal screening, precision medicine, disease risk & uncertainty in predictive diagnosis, pharmacogenomics	None or very basic knowledge of genetics & genomics	Podcast + resources	None	General physicians	Unknown	Contributes to CPD	Ongoing
Genomics in the Clinic: A Workshop for Health Professionals	Melbourne Genomics	VIC	Genetic & genomic sequencing, genomic testing, variant interpret-ation & applying results to patient care	Basic genetics & genomics knowledge	F2F 1-day workshop	Pre- & post-workshop survey re satisfaction	Non-genetic health prof.s, nurses, allied health, health executives	As intended: 44% non-gen. health prof.s, 9% nurses, 27% scientists, 5% bioinf., 7% health ad-min, 9% other	None	Ongoing
Genomics in Newborn Screening (NBS): Potent-ial Targets & Benefits; 50th Anniversary NBS Symp-osium	VCGS	VIC	Invited Australian expert NBS speakers reflected on history, current practice & possible futures of NBS	None	F2F	None	Health professionals	Unknown	Unknown	N/A

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
Genomics Workshop	HGSA	TAS	Diagnostic, technical issues in NGS clinical application, detecting & interpreting WE/GS sequencing variants Cases studies	Unknown	F2F	Unknown	Conference attendees (genetic researchers)	Unknown	Unknown	N/A
Introduction to Nutritional Genomics	Monash University	VIC	Basic genetics & nutritional genomics, clinical application & personalised nutrition. Run 2015 and 2/yr since	None or very basic know-ledge of genetics & genomics	Online, 5-weeks, 4 hr/week. Lectures + case studies	Post-workshop survey re knowledge & satisfaction	Dietitians; non-genetic health prof.s s	As intended + nutritionists	None	Ongoing, 2/yr User pays: $450
Introductory Human Genome Bio-informatics workshop	Uni. New South Wales; Prince of Wales Clinical School	NSW	Overview bioinformatic resources, basic practical bioinf. skills. Began in 2014	U'grad qualification	F2F 2-day workshop	Post-workshop survey re satisfaction.	Researchers; med.sci; bioinf.	As intended + gen.path., biobank managers, some clinicians	None	Ongoing annual. May be uni subject in 2018 Free
Introductory Short Course in Medical Genetics & Genomics	Royal College of Pathologists Australasia	National	Clinical applications of genetic/ genomic testing. Run in 2016 as 4-day program then revised to 3-day in response to participant feedback	Knowledge at level of recent "undifferen-tiated" medical graduate	F2F 3–4-day program lectures + case studies + panel	Post-workshop survey re satisfaction at end of each day	Early stage RCPA non-gen.path. trainees (registrars)	⅓ as intended + ⅓ practising med.sci. + ⅓ RCPA fellows from non-genetic disciplines	Contributes to CPD	Ongoing every 2yrs
Learn About (Clinical) Genomics, Genetics PINTEREST page, publication database	Garvan Institute of Medical Research	NSW	Basic biology, clinical genetics & genomics, info re events relating to clinical genomics, key public-ations. Content updated 6-monthly	None	Online resources curated by genomics communic-ation & education specialist	None	Health professionals, researchers, teachers, gov't & philanthropic reps.	As intended + general public	None	Ongoing
Lifestyle Inter-ventions & Personalised Medicine Approach to Healthy Ageing	AAAM; ASL; ATMS; ANTA; Comple-mentary Med. Assoc.	VIC	Lifestyle and ageing aspects that impact nutrition and food choices Last run 2016	Unknown	F2F workshop	Unknown	Allied health; complement-ary medicine practitioners; health professionals	Unknown	Unknown	User pays; $550-600
Molecular Karyotyping: New Advances in	QML Pathology Service	National	Understanding & interpreting molecular karyotyping in clinical diagnostics. Varies re	None or very basic knowledge of genetics & genomics	F2F lectures + case studies	Post-workshop survey re satisfaction	Health professionals ordering genomic tests	As intended	Contributes to CPD	Ongoing

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
Constitution-al & Prenatal Diagnostic Testing			audience needs, incl. case studies							
Pathology Update: Genetics Stream	Royal College of Pathologists Australasia	National	Cutting edge practical applications of genetics	Medical or scientific background	F2F sessions at conference + CD/Website presentations	Post-workshop survey re satisfaction	Broader pathology disciplines	As intended + clinical scientists, RCPA "non-genetic" fellows, RACP clin.gen. fellows	Contributes to CPD	Ongoing
Practical Genomics: A 2-day Workshop for Genomics in the Clinic	Melbourne Genomics	VIC	Next generation sequencing, bioinf., variant interpretation, consent & ethics. Evolved from 2014 variant curation workshop. Also run in 2016	Qualifications in genetics/ genomics	F2F 2-day workshop + prac.	Pre- & post-workshop survey re knowledge. Post-workshop survey re satisfaction	Clin.gen., gen.couns.	75% as intended + 25% med.sci., researchers	Contributes to CPD	Ongoing; due 2017 Cost not stated
Precision Medicine: Public Lecture	University of Newcastle	NSW	Future of personalised health care in Australia and abroad, including benefits and implications of individualised medicine	None	Two-hour public lecture	Unknown	Public; health professionals	Unknown	Certificate of partici-pation available	Free
RCPA/ HGSA Case Studies	Royal College Pathologists Australasia; HGSA	National	Genetic case studies	Genetics & genomics knowledge	Online	Unknown	Non-gen.path. registrars, gen.path, Faculty of Science fellows & trainees	As intended + those working in genetic laboratories	Contributes to CPD	Not being updated
School of Personalised Immunology	Centre for Person-alised Immuno-logy, Aust. National Uni.	ACT	Basic molecular bio, latest genetic technologies for phenotyping and genomics medicine, proof of genetic causation, clinical immunology. Run 2015, 2016.	U'grad clinical or medical science, basic knowledge of genetics	F2F 1.5-day workshop + lectures	Pre- & post-workshop survey re satisfaction	Physician advanced trainees, GP registrars, health prof., early career immunology sci., med. students	2015: med. trainees & clinicians, sci., path. 2016: sci. & clinicians	No formal accredit-ation	Ongoing annual Cost not stated
Short Course in Medical Genetics & Genetic Pathology	Royal College of Pathologists Australasia	National	Developments in human genetics & genomics relevant to clinical service provision. Biennial since 2011. Recently revised to	"Genetic Pathology" trainees, both medical & science streams	F2F 4-day lectures + panel discussions	Post-workshop survey re satisfaction at end of each day	Broader pathology disciplines	As intended + clinical scientists, RCPA "non-genetic" fellows, RACP	Contributes to CPD	Ongoing annual

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
			annual 1-day Advanced training/ update for same audience (held at annual RCPA PathUpdate)					clin.gen. fellows		
Sydney Genomics Collaborative Scientific Symposium	KCCG, Garvan; NSW Health	NSW	Updates on Sydney Genomics Collaborative programs and KCCG activities.	NSW genomics community	Free of charge	Symposium	Clin.gen., gen.couns., researchers	Unknown	Unknown	Ongoing annual
Understand-ing Informed Genomic Consent	Centre for Genetics Education	NSW	In development	Medical qualification with specialised training	Podcast + case study	Pre- & post-surveys re knowledge, attitude, satisfaction with teaching method	Non-genetic health professionals ordering genomic tests	tbc	Will contribute to CPD	Due 2018
Variant Curation Workshop	Melbourne Genomics	VIC	Variant curation, from bioinf. pipeline to reporting	Qualifications in genetics/ genomics	F2F 2-day workshop + lectures prac.s	Pre- & post-workshop survey re knowledge & satisfaction	Clin.gen., gen.couns., non-genetic health prof.s, bioinf., med.sci	As intended	None	Ongoing, 2017
Whole Genome Sequencing Data Analysis	QLD Facility Advanced Bioinforma-tics	QLD	Intro to NGS theory; intro to Galaxy	Unknown	F2F 1.5-day workshop	Unknown	Bioinf.	Unknown	Unknown	Unknown Cost not stated
Winter School in Mathe-matical & Computat-ional Biology	Uni. Queens-land	QLD	Introductory bioinformatics, mathematical and computational biology.	Unknown	F2F	Unknown	Bioinf., adv. u'grad & p'grad students, postdoc., researchers in biology, maths, statistics, comp sci., info. tech., complex sys-tems analysis, chemical & medical sci., & engineering	Unknown	Unknown	Ongoing User pays: $235-390

Table C- 3. Details of MOOCs, including host, content, delivery and audience

Name	Host organ-isation	Location	Content	Req. prior knowledge or skills	Delivery method	Evaluation	Intended audience	Actual audience	Certifi-cation	Status
Epigenetic Control of Gene Expression	Uni. Melbourne	VIC	Intro to epigenetic control & interplay with environment, aberrant epigenetic control in disease. Run 1x 2013, 2014, 2015, 4x 2016, 2017	U'grad qualification, basic back-ground in bio./genetics recommended	Online 7-weeks, 6–8 hr/week. Lectures, quizzes projects + forums	Pre- & post-MOOC survey to assess satisfaction & knowledge	Advanced u'grad students	Health prof.s & PhD students (50%), others	Can con-tribute to CPD (fee for certific-ate)	Ongoing
Myths & Realities of Personalised Medicine: The Genetic Revolution	Uni. New South Wales	NSW	Impact of personalised medicine on clinical practice, including ethical, legal & psychosocial issues. Run in 2015 via Coursera; 2016–17 via FutureLearn	None	Online 5-weeks, Lectures, quizzes, case studies + forums, plus video feedback	Pre- & post-workshop survey re knowledge showed increases	General public	As intended incl. scientists, nurses & other health prof.s	Can con-tribute to CPD (fee for certifi-cate)	tbc