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Core Competencies in Cancer Genomics for Healthcare Professionals: Results From a Systematic Literature Review and a Delphi Process

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Abstract

The continuous development and use of genomic sequencing requires healthcare professionals to constantly integrate these advancements into their clinical practice. There is a documented lack of cancer genomics contents in the teaching and learning programs. We aimed to identify the core competencies in cancer genomics for non-genetic healthcare professionals. We performed a literature review in PubMed, SCOPUS, and Web of Science databases to retrieve articles published from 2000 to 2018, in English or Italian language. We included articles that reported the competencies for non-genetic healthcare professionals in cancer genomics. A web-based modified Delphi survey was conducted, aiming to define, through consensus, a set of core competencies that should be covered in the curricula. The international expert panel included specialists in genetics, genomics, oncology, and medical specialists. In the literature review, we retrieved nine articles, from which we identified core competencies for general physicians and nurses. The competencies were organized in three main domains: knowledge, attitudes, and practical abilities. In the second round of Delphi survey, consensus of 83.3% was reached for the definition of the core competencies. Thirty-seven items were defined as the competencies required for physicians and forty-two items for nurses. Through a consensus-based approach, a set of core competencies in cancer genomics for non-genetic healthcare professionals has been identified. Our findings could benchmark standards for curriculum development and future educational strategies.

Keywords Genomics · Cancer · Competences · Healthcare professionals

Introduction

With the advancements in sequencing technologies and computational approaches, healthcare professionals can understand the genomic underpinnings of cancer development and treatment [1]. The information about genomic profiling of cancer is helping to comprehend genetic alterations and oncogenic mechanisms of many types of cancer [2]. This knowledge is leading to identification of new diagnostic methods and targeted treatments [1]. As genomic technologies rapidly evolve, genomics knowledge has become of utmost importance to healthcare practitioners, regardless of the field of practice [3]. Over the last decade, the expansion of genomics into clinical practice has resulted in an increased use of genomics by non-genetic healthcare professionals (NGHPs), such as primary care providers, oncologists, or gynecologist [4].

The increased accessibility of genomic technology is changing the educational requirements of healthcare professionals [5]. The inadequate genomics knowledge and skills create a lot of challenges for genomic data interpretation and communication, thus depriving patients from making informed treatment decisions [6]. A recent systematic review that investigated the level of knowledge among physicians in clinical cancer genomics reported limited levels of genomic literacy, which varied by specialty, type of genomic services, and years of practice [7]. An appropriate and effective implementation of cancer genomics requires genomically literate healthcare professionals as well as implementation of well-defined genomics core competencies.

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Competencies, defined as a healthcare professionals' potential to apply knowledge and abilities successfully when performing a specific task [8], are used to guide the development of educational programs [9]. The pre-requisites for the identification of the core competencies include a two-step process: firstly identifying and, then defining the essential competencies [9]. A set of core competencies in genetics for NGHPs have been identified [10] whereas, in cancer genomics, these competencies have not been established yet. The lack of a defined set of competencies required in cancer genomics poses challenges to the development of educational programs aiming to improve the genomic literacy.

Recently, the Innovative Partnership for Action against Cancer (iPAAC), a European initiative that addresses also cancer genomics education aiming to improve the genomic literacy among healthcare professionals, was established [11]. The present article has been developed as part of this initiative, with the aim to provide the core competencies in cancer genomics in order to address the needs for structured guidance on genomic education for graduate NGHPs.

Methods

The present article was developed in a two-step process. As the initial step, the core competencies were identified through a systematic literature review. In the second step, we implemented a survey according to a modified Delphi method in order to define a final set of core competencies.

Literature Review

Search Strategy and Study Selection

We performed a literature search of PubMed, SCOPUS, and Web of Science databases in order to identify articles reporting a set of core curricula for healthcare professionals in the field of cancer genetics and genomics. The PubMed search strategy is highlighted below:

("Physicians"[Mesh] OR "Health Personnel" [Mesh]) AND (genetic OR genetics OR genomics OR genomic OR genome) AND (knowledge OR education OR competence OR competencies OR competency OR competencies OR attitude OR attitudes OR curriculum OR curricula OR ability OR abilities OR skill OR skills) AND (cancer OR oncolog OR malignancy OR tumor OR tumour OR neoplasm)*

The search was limited to English or Italian language articles published from 2000 to 2018. Two investigators (AT; JS) independently screened potentially eligible titles and abstracts. This process was followed by an extensive analysis of full-text papers. We performed a snowball search of references from the eligible studies in order to find additional publications. Disagreements among the authors were resolved through discussion until consensus was reached. We developed the systematic review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12].

Inclusion and Exclusion Criteria

Our eligibility criteria included studies that reported the following: (1) set of competencies in cancer genetics or genomics for graduated healthcare professionals, according to the three domains of theoretical knowledge, relational attitudes, and practical abilities; (2) description of the methodology used to identify the competencies or clear reference to the scientific society that developed the set of competencies.

Data Extraction

Two authors (AT; JS) performed the data extraction, retrieving the following information: first author (or the name of the scientific society), publication year, country, target professionals, focus topic of the article (either cancer genetics/genomics or genetics/genomic in general with a sub-focus on cancer), and the methodology that was implemented to obtain the competencies. In addition, we screened and summarized all the competencies reported in the eligible articles according to the three domains of theoretical knowledge, relational attitudes, and practical abilities [10].

Delphi Process

The results obtained from our literature review were used to perform a Delphi procedure aimed to select the competencies to include in the curricula. This qualitative research method, developed by the Rand Corporation in the 1950s, aims to reach a consensus among experts through a series of reiterated questionnaires on a given topic. At the end of each round, a new set of questions is defined based on the results of the previous round. The process is repeated until a consensus is reached [13].

The procedure used in the present study consisted of a modified version of the Delphi process. Eight international experts, in the field of genetics and genomics, from UK, Italy, Belgium, and Slovenia, were involved in this Delphi procedure. The invited experts were involved in the research activities within Work Package 6 "Genomics in cancer Control and Care" of the iPAAC project, part of which is also this study [11]. The participants received the invitation, along with the description of the study, via e-mail. We asked the participants about their age, gender, professional activity (medical geneticist, oncologist, medical doctor, pharmacist, biologist, nurse, etc.), and their years of professional activity within the field of genetics. The participants were not asked any question related to their identity, such as name, country, or e-mail address. Therefore, the entire procedure was conducted anonymously and a disclosure of conflicts of interest was

requested from the participants. Following the initial invitation, a series of reminders were sent by e-mail in order to increase the response rate. The invitation e-mail and the reminders were sent to all of the eight experts in each Delphi process step.

We elaborated the Delphi first-round questionnaire from the results retrieved from the literature review. During this first round, the experts could propose additional competencies based on their own experience. The questionnaire was composed of three groupings: the first group included section one that collected demographic information regarding age, sex, professional qualification, and years of work experience in genetics; the second group included sections two to four, which were related to the competencies within the domain of *Knowledge, Attitudes*, and *Abilities* to be included in the physician curriculum; and the third group included the sections from five to seven which regarded, instead, the competencies within the domain of *Knowledge, Attitudes*, and *Abilities* to be included in the nurses curriculum. The sections from two to seven asked participants to rate the competencies as "*Important*" (if the item should be included in the curriculum as it is), "*Not important*" (if the item should not be included in the curriculum), or "Other" (if the specific competence should be included but in a modified version, and in this case, the participants were asked to specify the proposed modification).

At the end of the first round, the results were processed as follows: if an item was rated as "*Important*" by at least 70% of the respondents, it was directly included in the curriculum; if the item was rated as "*Not Important*" by at least 70% of the respondents, it was directly excluded. Afterwards, the items were proposed again in the second round, along with the modifications suggested by the experts. Two authors (IH; AA) evaluated the suggested modifications and integrated them into the respective items.

During the second round, the experts were asked to select "Yes," if they would include, or "No," if they would not include the item in the curriculum. As for the first-round results, the threshold for inclusion or exclusion was 70% of respondents. At the end of the second round, a consensus was reached among respondents and the results were returned to the participants.

Results

Literature Review

Study Selection

After removing duplicates, the database search retrieved a total of 1030 articles of which 991 were excluded after title and abstract screening, as not related to the research topic. The remaining 39 articles were assessed for eligibility and 31 were excluded because they did not meet the inclusion criteria. An additional study was identified through hand-searching the reference lists of relevant studies [14]. Nine studies were included in the systematic review [14–22]. A flow diagram of the studies selected or excluded at each stage, with reasons, is provided in Fig. 1.

Study Characteristics

Table 1 describes the main characteristics of the nine selected studies from the literature review. The studies period ranged between 2002 and 2017. Five studies were performed in the US [17–21], three in the UK [14–16], and one was performed in conjunction between the European and the American Societies of Oncology [22]. In regard to the target professionals, two studies [18, 22] were targeted at medical oncologists; three were targeted at non-geneticist physicians [15–17], three at oncology nurses [19–21], and one study was targeted at nurses, midwives, and health visitors [14]. Four studies were specifically focused on cancer genetics [16, 18, 19, 21], one on oncology topics [22], with a specific insight on genetic counselling, and the others were focused on genetics/genomics in general, with a sub-focus on cancer [14, 15, 17, 19]. When available, we reported in Table 1 the methodology the authors developed in order to implement the competencies.

Data Synthesis

The individual competencies from each of the nine studies were unified into two reports, one for physicians, and one for nurses, and divided into the aforementioned three domains. The report for physicians consisted of 12 competencies for knowledge, 10 for attitudes, and 22 for abilities. The report for nurses consisted of seven competencies for knowledge, 18 for attitudes, and 31 for abilities. All these items were proposed for evaluation in the Delphi survey.

Delphi Process

Six, out of eight invited healthcare professionals (75%), with specific expertise in genetics and genomics participated in the first and the second round. Regarding the experts' characteristics, the median age was 56 years (range 46–61) and the median time period of professional activity in the field of genetics was 22.5 years (range 5–35). Half of the respondents were female, and 67% (n = 4) were medical geneticists, one was a preventive oncologist, and the other was a medical doctor with other specialization. These characteristics of the respondents were the same in both Delphi rounds, suggesting that the same experts completed the questionnaire. No disclosed conflicts of interest were reported by the experts. The flow chart of the Delphi method is reported in Fig. 2.

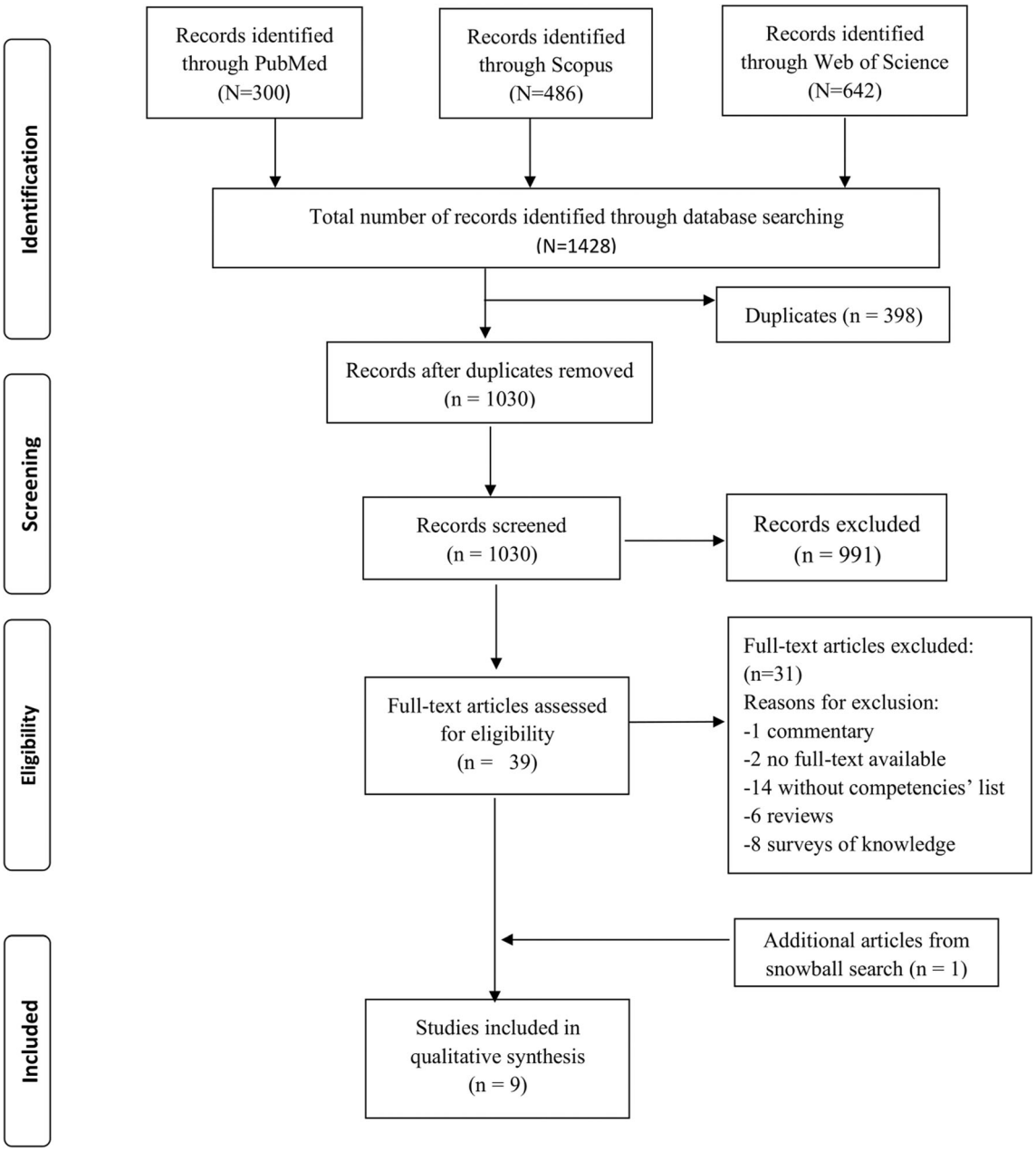

Fig. 1 Flow chart of the screening process and study selection in the systematic review

Regarding the items, in the first round, physicians' curriculum included 12 items for the domain of Knowledge, 10 items for the Attitudes, and 22 items for the Abilities (Supplementary Table 1). The nurses' curriculum, instead, included seven items for the domain of Knowledge, 18 items for the Attitudes, and 31 items for the Abilities (Supplementary Table 2).

At the end of the first round, seven items were excluded, of which two from nurses' knowledge and five from nurses' abilities, 17 items were modified (five from physicians' knowledge, four from physicians' attitudes, four from physicians' abilities, two from nurses' knowledge, and two from nurses' abilities), and four items for physicians' knowledge were additionally included. The rate of agreement among the respondents was 70%.

The second-round questionnaire included a total of 48 items for the physicians' curriculum, 16 items concerning the domain of Knowledge, 10 items the Attitudes, and 22 items the Abilities, and a total of 47 items for the nurses' curriculum, of which five concerning the Knowledge, 18 the Attitudes, and 26 the Abilities. At the end of the second and last round, a total of 37 items were included in the physicians' curriculum (Table 2): 16 items concerned the domain of Knowledge, seven items the domain of Attitudes, and 14 items the domain of Abilities. A final set of 42 items were eventually included for the nurses' curriculum: five items

Table 1 Characteristic of the nine articles included in the literature review

Study	Publication year	Country	Target professionals	Focus	Methodology
Eggert et al.	2017	USA	Oncology nurses	Cancer genetics	Review of the existing literature that highlights the learning and educational priorities in oncology nursing
Dittrich et al. *The European Society for Medical Oncology (ESMO) and the American Society of Clinical Oncology (ASCO)*	2016	Europe & USA	Medical oncologists	Oncology - focus on genetic counselling	*NR*
Robson et al. *On behalf of The American Society of Clinical Oncology (ASCO)*	2015	USA	Medical oncologists	Cancer genetics	*NR*
Korf et al. *On behalf of The Genomic Medicine Competencies Working Group of the Inter-Society Coordinating Committee for Physician Education in Genomics (ISCC)*	2014	USA	Physicians	Genomics in general with sub-focus on cancer	The Competencies Working Group defined five entrustable professional activities (i.e., professional activities that together constitute the mass of critical elements that operationally define a profession) that comprise a basic set of genomic skills: (1) family history; (2) genomic testing; (3) treatment based on genomic results; (4) somatic genomics: use genomic information to guide the diagnosis and management of cancer and other disorders involving somatic genetic changes; (5) microbial genomic information
Jenkins et al.	2011	USA	Oncology nurses	Genetics in general with sub-focus on cancer	Review of literature and research reports for advancing oncology nursing competencies in genetic/genomics through the illustration of case scenarios in clinical care
Burke et al.	2009	UK	Non-genetics specialist registrars	Genetics in general with sub-focus on cancer	1.Modified Delphi process; 2. Consultation with representatives from different specialties to revise the learning outcomes
Bennett et al. *"The NHS National Genetics Education and Development Centre"*	2007	UK	Non-genetics practitioners	Cancer genetics	Discussion (workshop) and questionnaire, based on previous experience developed by Department of Health in collaboration with Macmillan Cancer Support (setting up projects to pilot the integration of cancer genetics in mainstream medicine)
Kirk et al. *Final Report to the Department of Health NHS Genetics Team Prepared by the Genomics Policy Unit, University of Glamorgan, and the Medical Genetics Service for Wales, University Hospital of Wales*	2003	UK	Nurses, midwives, and health visitors	Genetics in general with sub-focus on cancer	A four-phase process was used overseen by a Steering Group: defining and refining the competencies; consultation; assimilation of responses; completing the framework. Five settings were considered, one of which is cancer
Calzone et al.	2002	USA	Advanced practice oncology nurses	Cancer genetics	Delphi technique: 1st round: open-ended responses to identify skills, attitudes, and competencies. 2nd ranking of the importance

NR not reported

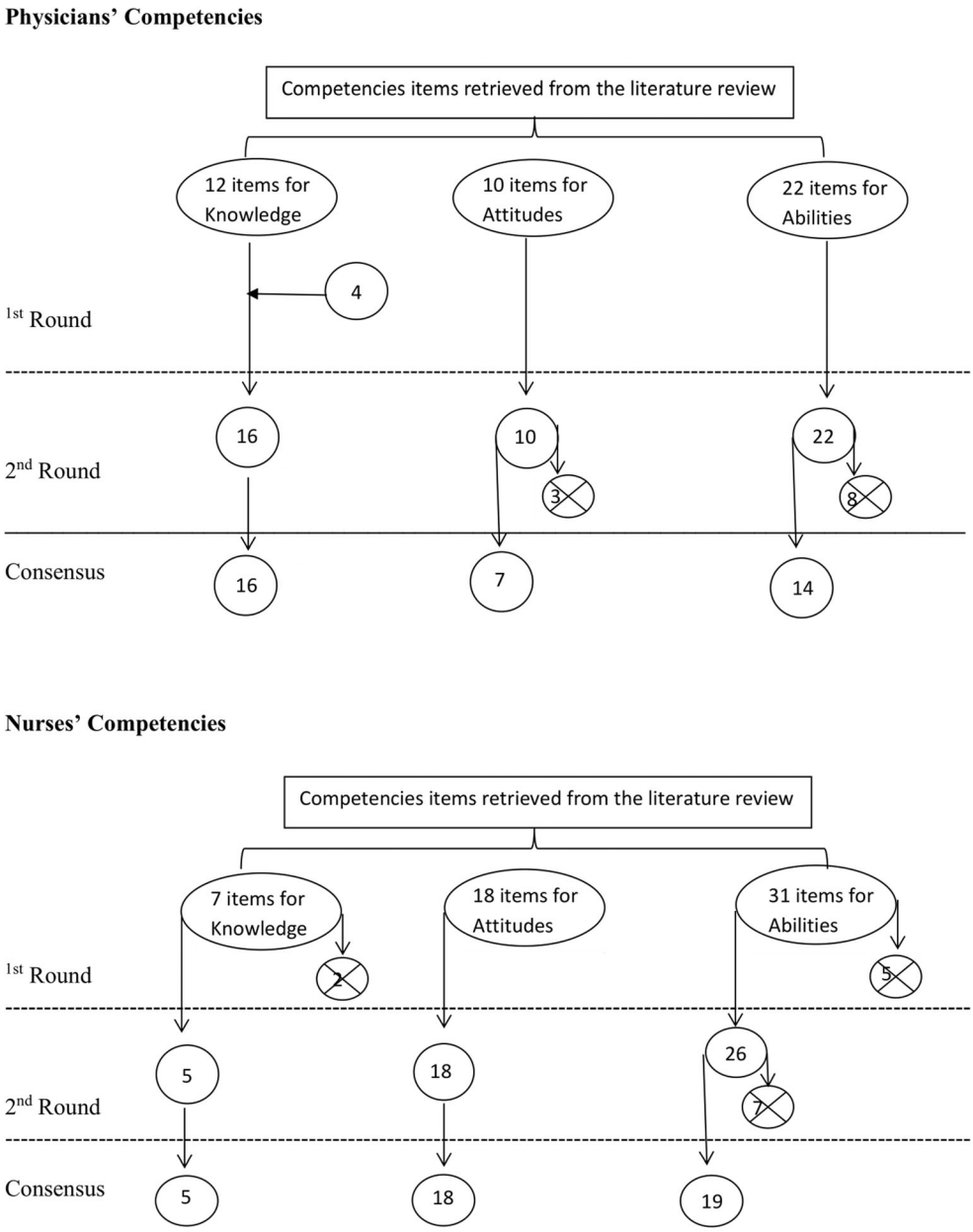

Fig. 2 Flow chart of the results of the Delphi process

regarded the nurses' knowledge, 18 the nurses' attitudes, and 19 the nurses' abilities (Table 3). The rate of agreement among the respondents for the second round was 83.3%.

Discussion

In this study, we identified the core competencies that graduate NGHPs should acquire in cancer genomics, with a particular focus on physicians and nurses. The core competencies were identified through a literature review and, afterwards, were defined by a Delphi method with international experts in the field of genomics and genetics. This was the first attempt to develop a consensus on the competencies needed for NGHPs in cancer genomics. The core competencies were generated from a high level of consensus among the experts in the final Delphi round.

Several studies have reported that NGHPs have insufficient knowledge on cancer genomics and they perceive as difficult tasks the family history taking, risk communication, or genetic test result interpretation [23]. Healthcare professionals are required to have a set of core skills and knowledge in order to evaluate family history and to recognize clinical findings that indicate potentially increased hereditary cancer risk. Genetic/genomic information to patients or at-risk family members has been explained by trained medical geneticists and genetic counselors. However, this task is necessary also for NGHPs caring for cancer patients, which could inform, in an

Table 2 Final physicians' core competencies defined through the Delphi method

Physicians' core curriculum
Knowledge competencies
• Basic knowledge of genetics within your own field of clinical practice
• Knowledge of the concept of somatic genetic change
• Knowledge of the role of genomic changes in the pathophysiology and treatment of cancer
• Understanding the hereditary predisposition to cancer, including the polygenic and multifactorial nature of cancer risk
• Knowledge of the major hereditary cancer syndromes
• Understanding the specific characteristics of hereditary cancer syndromes that may distinguish them from sporadic cancers
• Knowledge on how genomic testing can be used to guide therapy and dose selection in patients with cancer
• Knowledge of the availability of screening tests and procedures for those identified as having higher lifetime risk
• Understanding genetic testing types and results' interpretation
• Awareness of incidental and secondary findings from somatic tumor profiling
• Defining the general characteristic of tumor spectrum of known syndromes
• Awareness of overlapping phenotypes for the common syndromes that generate differential diagnosis for hereditary syndromes based on presenting cancer
• Knowing the interpretation and the importance of family history in assessing predisposition to disease
• Understanding the differences between hereditary and nonhereditary cancers
• Understanding the importance of family history as a risk factor, regardless of gene testing
• Awareness of risk-reducing measures in high-risk patients and relatives, including chemoprevention and prophylactic surgery
Attitudes competencies
• Confirm that tissue biopsy procedures are coordinated to ensure that appropriate and sufficient material is obtained for testing
• Keeping up a dialogue with the clinical laboratory to ensure that the appropriate test(s) are ordered and interpreted in the context of the patient's clinical status
• Being continuously informed about the progress in the diagnosis and treatment of cancer
• Acknowledging the impact of genetic information on the patients and their family
• Recognizing the need for consents to disclose a particular diagnose to relatives
• Recognizing the importance of multidisciplinary work and the role of genetic counselors as well as mental health professionals to assist patients as they process difficult information
• Using appropriate language and cultural skills to raise awareness in a community and to help patients to access the genetic service
Abilities competencies
• Ability to draw a pedigree by using a multi-generational family history
• Ability to assess/ interpret pedigrees
• Ability to integrate genomic testing results into the patient-care plan
• Communicating genetic information to patients by using language and cultural awareness skills
• Ability to make appropriate to genetic services, for risk reduction recommendations strategies in patients with hereditary cancer syndromes
• Ability to give advice and discuss cancer preventive screenings (such as mammography, colonoscopy)
• Ability to use genomic information to guide the diagnosis and management of cancer and other disorders involving somatic genetic changes
• Ability to describe the elements of pretest consent for cancer susceptibility testing
• Ability to contribute to multidisciplinary case presentations and to discuss risk assessment and diagnosis of common familial cancer syndromes
• Ability to illustrate the benefits and limitations of somatic genomic testing to the patient, including implications regarding treatment of the condition and clarification of his/her prognosis as well as limitations of genomic testing
• Ability to communicate to patients' potential implications for their family
• Ability to make appropriate referrals to specialists and other health providers as well as support the patient in ongoing care
• Ability to collaborate with other specialists to provide support for patients, ensuring that specialists involved in a patient's care are communicating with one another and with the patient
• Ability to work with genetic counselors/clinical geneticist to identify individuals and families with genetic mutations that increase cancer risk and to offer advice and guidance

understandable way, patients and their families about the essential information on heredity as well as treatment and/or preventive measures. Low confidence in the ability to record and collect information has been described as one of the

Table 3 Final nurses' core competencies defined through the Delphi method

Nurses' core curriculum
Knowledge competencies
• Familiarization with common adult conditions that suggest a genetic predisposition
• Knowledge and understanding of the role of genetic factors in maintaining health and preventing disease in particular inherited cancers
• Knowledge and understanding of the role of genetic factors in the manifestation of cancer, using examples of particular cancers more commonly encountered within own sphere of practice (e.g., colorectal, breast)
• Knowledge on the basic inheritance patterns, as well as the consequent health promotion issues
• Knowledge of evidence-based high-risk level for different inherited cancers to determine management guidelines (important for nurses in some clinical settings but not required for all)
Attitudes competencies
• Handling genetic information responsibly
• Awareness about the uncertainty associated with genetic information
• Awareness of the sensitivity and the complex psychosocial issues associated with genetic information
• Awareness of the unique aspects of genetic information
• Awareness of one's own attitudes and values related to genetic and genomic science and how they may affect care provided to clients
• Awareness about the importance of critical thinking in cancer genetics practice
• Awareness of the boundaries of knowledge and referring to another colleague with expertise in a particular area
• Awareness of the importance of updating the knowledge on genetics and genomics technologies and their implementation into oncology care
• Awareness about the values of research-based practice associated with genetic services and maintaining such attitude
• Avoiding to make assumptions about genetics without research findings
• Facilitating the inclusion of genetic information into the lives of patients (concerns for perceived risk of life-threatening, life-shorting disease and how to deal with the self-management of day-to-day care issues, information needs, stress, or coping demands)
• Advocating for clients' access to desired genetic/genomic services and/or resources including support groups
• Acknowledging the importance of tailoring genetic and genomic information and services to clients based on their culture, religion, knowledge level, literacy, and preferred language
• Awareness and respectfulness of autonomous genetic decision-making
• Awareness of consequences of cancer such as the emotional experiences associated with the diagnosis of cancer, the impact on the life of the patient and family as well as effects of treatment
• Awareness of the potential impact of the genetic information on patients' family members
• Advocating for the rights of all clients for autonomous, informed genetic- and genomic-related decision-making and voluntary action
• Demonstrating the will to collaborate with all members of the genetics healthcare team
Abilities competencies
• Ability to understand the patterns of inheritance and explain genetic inheritance of cancer and disease development
• Ability to elicit a minimum of three generation family health history information and to construct a pedigree using standardized symbols and terminology
• Ability to demonstrate an understanding of the effects of genetics and genomics on health, prevention, screening, diagnostics, prognostics, selection of treatment, and monitoring of treatment effectiveness
• Ability to understand different concepts of risk to distinguish between genetic susceptibility and clinical manifestation of a disease
• Ability to use health promotion/disease prevention practices that incorporate genetic and genomic information as well as personal and environmental risk factors (giving advice and discussing preventive management such as mammography, colonoscopy)
• Ability to identify ethical, ethnic/ancestral, cultural, religious, legal, fiscal, and societal issues related to genetic and genomic information and technologies
• Ability to identify individuals that may be potentially at risk of having a genetic predisposition to cancers
• Ability to apply knowledge and understanding to identify potentially significant information from a family history (being aware of the difference between inherited and acquired cancers)
• Ability to interpret to the clients selective genetic and genomic information or services
• Ability to facilitate the access of individuals to screening and health promotion initiatives, presenting a balanced view of the advantages and disadvantages of these
• Ability to define factors that undermine the rights of all clients for autonomous, informed genetic- and genomic-related decision-making and voluntary action
• Ability to: provide supportive care; deliver credible, accurate, appropriate, and current genetic and genomic information, resources, services, and/or technologies that facilitate decision-making for the clients; clarify the doubts and listen to the patient/family as the various decisions are considered

Table 3 (continued)

Nurses' core curriculum
• Ability to provide coordination of care associated with the delivery of cancer genetic services
• Ability to facilitate referrals to specialist sources of assistance including specialized genetic/genomic services and assisting with implementation of the management pl
• Ability to collaborate and consult with all members of the genetic multidisciplinary team
• Ability to create communication links between oncology and genetic healthcare providers
• Ability to refer the patients to appropriate cancer genetic research studies
• Ability to provide input to committees or groups establishing policies regarding genetic services
• Ability to plan and provide education about cancer genetics (by using appropriate adult learning principles, language, and cultural awareness skills in the delivery of complicated genetic education) as well as evaluate the effectiveness of the education provided

barriers to an adequate family history taking [24]. A recent survey among NGHPs reported less confidence in communication skills about genetic testing for hereditary cancer in those with lower knowledge level. Despite the limited knowledge, physicians have shown positive attitudes towards increasing their genomic literacy and integrating clinical genomics into cancer care [25]. A low to moderate genomic literacy has been described also among medical oncologists, which believe that medical training programs do not include sufficient genomic training [26]. Nurses as well have a gap in their understanding of the relevance of genomics in clinical care, probably due to the insufficient coverage of genomics into current education programs [27]. It has been noted that the lack of genomics content in the curricula has a negative impact in the perception of their utility into clinical practice [28]. In this context emerges the necessity for competency-based educational approaches.

The methodological strengths of the present work warrant mentioning. Flexibility of the Delphi process allows adaption of the method according to the requirements of a study [29]. Hence, considering that the items were identified through a literature review, we used the modified Delphi methodology [30]. The Delphi process, which has the advantages of being anonymous, was performed in a systematic and rigorous manner. The anonymity can reduce the coercion to conform to the viewpoints of dominant participants in the expert panel [13]. Despite the items identified through the literature search, the contents were enriched with other elements proposed or modified by the experts in the second round. The international composition of the expert panel, belonging to a wide range of related disciplines, may increase the generalizability of the results. We are not able to predict whether the results would have changed if the number of experts had been higher; however, the sample size of our expert panel is suitable for a Delphi process, as suggested previously [31]. The competencies were generated from an inter-agreement rate of 83.3% in the second round, which was even higher than the consensual rate reported in the literature [30], suggesting the validity of our results. The criticism of our study we should acknowledge is the fact that in the expert panel should have been included also a nursing expert that could have identified the competencies needed for genetic nursing in particular. However, the figure of a specialist genetic/genomic nurse is not available in all the countries [32], which is one of the challenges of nursing education in the area of personalized medicine. Moreover, the core competencies were identified through the systematic review, which included only available published articles in English and Italian, suggesting the presence of publication bias. The Delphi method has become an increasingly important method in developing consensual professional guidance and in identifying the competencies required for a variety of healthcare professionals, particularly when the available evidence is insufficient [10, 33, 34].

In conclusion, the core competencies for cancer genomics obtained after the Delphi process may provide useful insights for the development of competency-based curriculum for NGHPs. With the rapid pace of genomic science and genomic sequencing advancements, the clinical practices will change, and the competencies may evolve over time. However, a standard set of competencies is fundamental when developing and implementing educational programs, across national boundaries. The core competencies defined through a consensus Delphi method could be essential to the academics to refine the curriculum content and the learning outcomes in order to ensure competent healthcare professionals. Competencies can enhance the knowledge translation of cancer genomics into clinical practice, a slow and complex process. As sequencing technologies are now applied to detect mutations in human tumors and their cost continues to decrease, it is fundamental for NGHPs to be on the front lines of translation cancer genomics to clinical practice.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Research Involving Human Participants and/or Animals Not applicable.

Informed Consent Not applicable.

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