

Effectiveness of educational intervention types to improve genomic competency in non-geneticist medical doctors: a systematic review of the literature

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ABSTRACT

Background: Given rapid advances in genomics, continuing medical education of medical doctors (MDs) is crucial to ensure appropriate integration of human genome discoveries into healthcare and disease prevention. This work presents a systematic review of educational interventions aimed at improving genomic competency in non-geneticist MDs, with consideration of how outcomes are affected by intervention type (face-to-face learning, distance learning, decision aids, or information provision).

Methods: We performed a systematic search of MEDLINE, ISI Web of Science, and SCOPUS databases for the relevant studies on educational interventions and genomic competency, published in English between January 1st, 2001 and March 31st, 2017. We evaluated the effect of education on knowledge, management and confidence related to genomics ("genomic competency"), and we compared the outcomes between different intervention types. No meta-analysis was conducted, and results were presented narratively.

Results: We included sixteen studies assessing different educational interventions. The majority of studies reported significant effects on at least one component of genomic competency, in particular confidence outcomes. While many of the interventions cited positive self-reported changes in clinical application of genomic knowledge, there was no evidence of a statistically significant impact in the majority of studies that used objective measures to quantify clinical practice outcomes.

Conclusion: The majority of included studies reported a positive impact of genomic education on at least one component of non-geneticist MDs' genomic competency. However, no clear conclusion can be drawn given the heterogeneity of the studies in terms of methods, intervention types, and outcome measurements. Future studies considering the effectiveness of interventions with a focus on long-term outcomes across national contexts are recommended.

INTRODUCTION

The past few decades have seen rapid developments in genomic knowledge and technologies [1], although these have not yet been applied to their full potential in the public health sphere [2]. A workforce educated in genomics is a necessary aspect of addressing this. Many healthcare practitioners will not have received adequate training in this field; there are reports of a negative correlation between time since medical school graduation and knowledge of genomics [3]. Specifically, appropriate integration of genomics medicine into public health practice requires that non-geneticist medical doctors (MDs) have genomic competency – where “genomic competency” is defined as knowledge of genomics, and ability and confidence to apply genomic knowledge in medical practice.

This makes appropriate continuing medical education essential. Prior research in adult learning suggests that several aspects of an educational intervention may have impacts on its effectiveness, including the type of intervention, and the amount of practice-reinforcing strategies it contains. For example, it appears that interactive learning, including case studies, is generally more effective at improving medical knowledge than learning based on theoretical principles alone [4]. Similarly, a systematic review of a large number of trials reported that delivering continuing medical education via conferences was not very effective without practice-reinforcing strategies [5].

While there has been much literature on continuing professional education strategies in health professionals generally, there appears to be a dearth of research on how best to improve genomic knowledge, management, and confidence in non-geneticist MDs specifically. Therefore, the aim of this study was to conduct a systematic literature review of genetics educational interventions for non-geneticist MDs and to describe to what extent the type of educational intervention affects genomic competency outcomes.

MATERIALS AND METHODS

Search strategy

We searched MEDLINE, ISI Web of Science, and SCOPUS databases for the relevant studies on educational interventions and genomic competency, published in English between January 1st, 2001 and March 31st, 2017. We used the following terms for the literature search: (*course OR courses OR programme OR programmes OR program OR programs OR seminar OR seminars OR pedagogy OR education OR teaching OR training OR “continuous medical education” OR “continuing medical education” OR learning OR e-learning*) AND (*physicians OR physician OR doctor OR doctors OR “medical practitioner” OR “medical practitioners” OR practitioners*

OR practitioner) AND (*“genomic testing” OR “genomic knowledge” OR “genetic testing” OR “genetic knowledge” OR genomics OR genetics OR “genomic screening” OR “genetic screening”*) AND (*knowledge OR knowledges OR confidence OR ability OR clinical application OR competency OR skill OR attitude OR competenc**).

Two investigators (T.L., G.E.C.) independently reviewed titles, abstracts, and full texts of the retrieved papers in order to identify the eligible studies. Results were cross-checked and any disagreement was resolved through discussion until consensus was reached. The snowball strategy, a manual search of the references listed by studies retrieved from the online databases, was also adopted to identify additional studies. The systematic review was drafted in accordance with PRISMA checklist [6].

Eligibility criteria

The eligibility criteria for inclusion in this review required that the studies: 1) included data on outcomes of interventions on genetics education for non-geneticist MDs, 2) reported pre- and post-intervention scores for single-group study, and 3) were primary studies.

We excluded studies that: 1) provided combined information on educational interventions on MDs including geneticists without presenting the results by profession; or 2) focused on patient education.

Data extraction

We extracted the following information from the eligible studies: first author, year of publication, setting, study design, genetic content of the intervention, type of educational intervention, number and specialty of the physicians targeted by the interventions, outcome type (knowledge, management, or confidence), and main results.

Educational interventions are classified as face-to-face, distance learning, decision aids, and information provision; where decision aids indicate any tool specifically developed to support MDs in risk triage during patient consultation, and information provision means the provision of information in the form of reference literature and/or referral guidelines.

In order to evaluate educational outcomes of the interventions, we used the following categories based on aspects of the Kirkpatrick model [7]: knowledge (theoretical knowledge of genomics), management type I (clinical application of genomic knowledge with case-based scenarios), management type II (clinical application of genomic knowledge in real practice), and confidence in knowledge and/or application of knowledge.

Information on whether outcomes are measured objectively (e.g. through knowledge questionnaires, performance on case-studies, or quantitative measurements

of clinical behaviour) or subjectively (e.g. through a self-assessment) is reported.

Because of the heterogeneity of the studies in terms of methods, intervention types, and outcome measures, no meta-analysis was performed, and we present the findings in a narrative form [8].

RESULTS

Study selection

Our search yielded 153.865 records in the initial screening phase. After removing duplicates, we identified a total of 121.363 articles. Among them, 121.334 were excluded as unrelated to the research topic after title and abstract screening. The remaining 29 full-text articles were assessed for eligibility, and 13 were further excluded because they did not meet the inclusion criteria. The total number of studies included was 16 [9–24]. The Figure shows the study selection process and the results of the literature search.

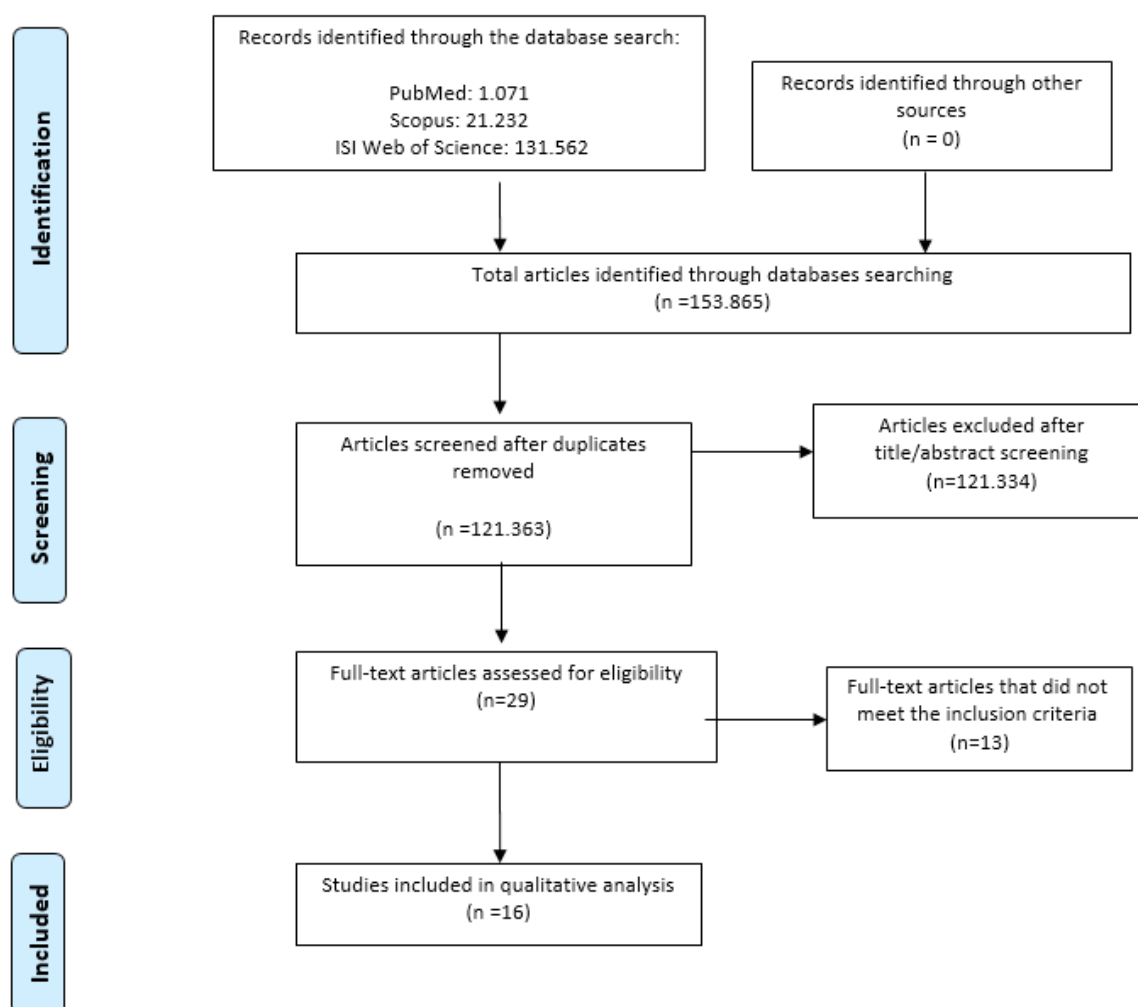
Study characteristics

The main characteristics of the studies included are reported in Table 1. Of the 16 studies, 4 were performed in the USA [12,15,19,24], three in Canada [14,16,18] and in The Netherlands [20–22], two in UK [9,11], one in Australia [10], one in Italy [23], and one in South Korea [17]. The intervention in the study by Hezservv Whers et al. [13] was conducted in an international setting, with participants from 13 different European countries and from Japan.

Eight studies have a single group study design [10,12,14,16–18,23,24], seven have two groups study design [11,13,16,19–22] and one has three groups study design [9]. Out of the studies with multiple-group study designs, seven are randomized [9, 11, 16, 19–22].

Four studies focused on interventions aimed to increase genomic competency in hereditary breast and/or ovarian cancers [9,11,17,19]. Four studies considered interventions aimed at improving competency in general genetics [12,14,23,24] and five in oncogenetics [15,16,20–22], while three studies investigated interventions to

FIGURE 1. Flow diagram of study selection process.



improve genomic competency in prenatal screening [10], genetics of epilepsy [13], and hereditary colorectal cancer [18], respectively.

Concerning educational interventions, five studies investigated face-to-face interventions [12,14,17,21,24], two distance learning [20,23], one decision aids [18], while eight studies analyzed several intervention types in combination or comparison with one another [9–11,13,15,16,19,22]. The number of MDs included in the studies ranged from 16 [17] to 426 [9], with primary care practitioners as the main specialty of the physicians targeted by the interventions.

Regarding intervention outcomes, twelve studies evaluated multiple outcomes [9–12,14–18,20,21,24]. Ten studies evaluated knowledge outcomes [10,12–17,20,23,24], eight management I [9,10,15,16,18,19,21,24], eight management II [11,12,15,18,20–22,24], and nine confidence outcomes [9–11,14–18,24] (Table 1).

To facilitate a comparison of the studies, Table 2 reports the main findings for each outcome analyzed, by intervention type.

The majority of the studies reported statistically significant effects of the intervention in question on at least one component of genomic competency.

Concerning knowledge outcomes, face-to-face and distance learning interventions significantly improved objectively measured knowledge scores [12, 14, 17, 24, 23], also when combined [15], and when face-to-face learning was considered together with information provision [10]. Hezserv. Wehrs et al. [13] found that distance learning combined with information provision performed better than information provision alone. However, Carroll et al. (2011) [16] reported that participation in a combined intervention of face-to-face + distance learning + decision aids + information provision did not significantly increase the probability of answering knowledge questions correctly, compared to participants with information provision only.

Management type I outcomes was the only outcome type considered across all the intervention types. Significant objectively measured improvements for this outcome pre-post is reported for face-to-face interventions in combination with information provision [10] and distance learning [15], and for multiple intervention types [16].

Most studies considering Management type II outcomes found no statistically significant effect across different intervention types [11, 22, 12] when progress was monitored with objective measures. The exception to this was Blazer et al. [15], where a significant increase in clinical outcomes was reported with objective measures. Only one study [18] found no significant change in subjectively reported management type II outcomes.

Confidence outcomes were significantly improved in all studies that considered them, with the exception of one [11].

DISCUSSION

This systematic review aimed to identify studies evaluating educational interventions for improving genomic competency in MDs, and to assess whether the learning types of the interventions are related to their effectiveness.

All the educational intervention types studied had a positive effect on at least one component of genomic competency. Knowledge and management I (objectively assessed) were significantly positively affected in the majority of the instances where they were considered as outcomes.

Meanwhile, in the included studies, significant change in clinical practice (management II) was more common when participants were asked to give a subjective estimation of how their behavior in clinical practice had changed, than when objective measures were applied. On the one hand, it is possible that participants perceive an educational intervention to be more impactful than it is, but on the other, real changes in clinical practice may not be reflected in objective outcomes such as referral numbers. This area warrants further research, as the answer has implications for how far an educational intervention impacts health outcomes – the ultimate outcome of interest in any medical service.

Another area for future research is the combined effects of different interventions. There is evidence to suggest that combinations of intervention types produce better results [5, 21]. However, the one intervention that incorporated all learning types in this review performed well against control (information provision only) for confidence and case-based management performance, but no better for knowledge outcomes [16].

The most common genomic topics addressed in the interventions were hereditary cancers and oncogenetics. Over the past two decades, the number of primary care referrals to genetics clinics on account of a family history of cancer has increased dramatically. This suggests that primary care practitioners will play an increasingly important role within a genomics medicine service; both in supporting patients through diagnostic and treatment processes, and in using knowledge of genomics for disease prevention [25]. For this reason, there is a need for interventions to improve the knowledge base of primary care practitioners specifically in order to integrate genetics services into family medicine.

A systematic review of educational interventions in genetics among primary care doctors has been published recently [26]. The authors reported that only prolonged exposure to genetic educational initiatives could generate significant changes in knowledge and clinical practice in the areas of recognition of genetic risk, assessment of risk, and appropriate management of patients. The present review did not consider length of exposure to an educational intervention, and this area requires further investigation.

As reported in primary studies included in our

TABLE 1. Characteristics of the included studies (N=16).

First Author, Year [Ref]	Setting	Study Design	Genetic content	Educational Interventions ^a	No. participants	Specialty of MDs	Outcome type ^b
Watson, 2001 [9]	UK	3- group cluster randomized	Hereditary Breast/Ovarian Cancer	(FTF+IP) vs control IP vs control	FTP + IP: 140 IP: 124 control: 162	GP	Management I, Confidence
Metcalfe, 2005 [10]	Australia	1-group	Prenatal Screening	(FTF+IP) pre-post	94 (completed pre-post) 63 (completed additional follow-up)	GPs	Knowledge, Management I, Confidence
Wilson, 2006 [11]	UK	2- group cluster randomized	Hereditary Breast Cancer	(DA+IP) vs IP	DA+IP: 151 IP: 92	GPs	Management II, Confidence
Clyman, 2007 [12]	USA	1-group	General Genetics	(FTF+IP) pre-post	36(of which 18 residents)	GPs	Knowledge, Management II
Hezser-v. Wehrs, 2007 [13]	International: participants from 13 European countries and Japan	2- group non-randomized	Genetics of Epilepsy	(DL+IP) vs IP	DL + IP: 20 IP: 16	Physicians	Knowledge
Blaine, 2008 [14]	Canada	1-group	General Genetics	FTF pre-post	93	GPs	Knowledge, Confidence
Blazer, 2011 [15]	USA	1-group	Oncogenetics	(FTF+DL) pre-post	48	Physicians	Knowledge, Management I & II, Confidence
Carroll, 2011 [16]	Canada	2- group randomized	Oncogenetics	(FTF+DL+DA+IP) vs IP	(FTF+DL+DA+IP): 47 IP: 33	GPs	Knowledge, Management I, Confidence
Lee, 2013 [17]	South Korea	1-group	Hereditary Breast/Ovarian Cancer	FTF pre-post	16	Physicians	Knowledge, Confidence
Carroll, 2014 [18]	Canada	1-group	Hereditary Colorectal Cancer	DA pre-post	75	GPs	Management I & II, Confidence
Bell, 2015 [19]	USA	2- group randomized	Hereditary Breast Cancer	DL vs IP	DL: 60 IP: 61	GPs	Management I
Houwink, 2014 [20]	The Netherlands	2- group randomized	Oncogenetics	DL vs control	DL: 20 control: 24	GPs	Knowledge, Management II
Houwink, 2014 [21]	The Netherlands	2- group randomized	Oncogenetics	FTF vs control	FTF: 38 control: 18	GPs	Management I & II
Houwink, 2015 [22]	The Netherlands	2- group randomized	Oncogenetics	(DL+DA) vs (FTF+DA)	(DL+DA): 42 (FTF+DA): 50	GPs	Management II
Michelazzo, 2015 [23]	Italy	1-group	General Genetics	DL pre-post	142	GPs, neurologist, gynecologist, oncologists, physicians working in preventive medicine departments	Knowledge
Reed, 2016 [24]	USA	1-group	General Genetics	FTF pre-post	20-30	Family physicians, internal medicine, obstetricians, pediatricians	Knowledge, Management I & II, Confidence

^a FTF: Face-to-Face; DL: Distance-Learning; IP: Information Provision; DA: Decision Aid; Control: no training;

^b Management I concerns clinical application of genomic knowledge with case-based scenarios; Management II concerns clinical application of genomic knowledge in real practice.

systematic review, the majority of educational projects to enhance understanding of genetics have been based in

a single country, which may limit the generalizability of the results. Partly to address this type of issue, a European

TABLE 2. Main Findings for each outcome investigated, by intervention type.

Intervention type ^a	First author, year [Ref]	Main results ^b			
		Knowledge (objective/subjective)	Management I (subjective/objective)	Management II (objective/subjective)	Confidence (objective/subjective)
FTF	Clyman, 2007 [12]	Significant improvement pre-post (objective)	-	No discernible effect of intervention (objective)	-
	Blaine, 2008 [14]	Significant improvement pre-post (objective)	-	-	Significant improvement pre-post (subjective)
	Lee, 2013 [17]	Significant improvement pre-post (objective)	-	-	Significant improvement pre-post (subjective)
	Houwink, 2014 [21]	-	Significant improvement pre-post (objective)	100% of responding reported using knowledge weekly/monthly in clinical practice (subjective)	-
	Reed, 2016 [24]	Significant improvement pre-post (objective)	Significant improvement pre-post (objective)	Large majority of participants reported change in clinical practice (subjective)	Confidence increased for all topics, but statistical significance was not reached in areas relating to risk triage and genetic testing (subjective)
DL	Houwink, 2014 [20]	Significant improvement pre-post, and in intervention vs. control (objective)	-	90% of participants reported they applied the knowledge gained monthly (measured in intervention only) (subjective)	-
	Michelazzo, 2015 [23]	Significant improvement pre-post (objective)	-	-	-
DA	Carroll, 2014 [18]	-	Significant improvement pre-post (objective)	No significant change in self-reported clinical practice (subjective)	Significant improvement pre-post (subjective)
FTF + IP	Metcalfe, 2005 [10]	Significant improvement pre-post, remaining at long-term follow-up (objective)	Significant improvement pre-post, remaining at long-term follow-up (objective)	Significant improvement pre-post, remaining at long-term follow-up (subjective)	Significant improvement pre-post; less at long-term follow-up (subjective)
FTF + DL	Blazer, 2011 [15]	Significant improvement pre-post (objective)	Significant improvement pre-post (objective)	Significant increase in a range of practice outcomes related to genetic counselling and screening (objective)	Significant improvement pre-post (subjective)
FTF + IP IP Control	Watson, 2001 [9]	-	FTF + IP performs similarly to IP alone (objective)	-	IP better than no training; FTF + IP better than IP alone. (subjective)
DA + IP IP	Wilson, 2006 [11]	-	-	No significant effect of intervention on appropriate referrals (objective)	No significant effect of intervention for any topic apart from "reassuring low-risk patients" (subjective)
DL + IP IP	Hezser-v. Wehrs, 2007 [13]	Significant improvement for DL + IP vs IP (objective)	-	-	-
FTF + DL + DA + IP IP	Carroll, 2011 [16]	No statistically significant difference between FTF + DL + DA + IP and IP groups (objective)	Significantly higher score for FTF + DL + DA + IP vs IP groups (objective)	-	Significantly higher score for FTF + DL + DA + IP vs IP groups (subjective)
DL IP	Bell, 2015 [19]	-	No significant difference between DL and IP: Significant changes in DL vs IP only in 6/69 topics rated (objective)	-	-
DL + DA FTF + DA	Houwink, 2015 [22]	-	-	Significantly higher percentage of participants reported desirable outcomes for FTF+DA vs DL+DA, although both showed increase pre-post (subjective); No significant difference in referral rates between groups, or within groups pre-post (objective)	-

^a FTF: Face-to-Face; DL: Distance-Learning; IP: Information Provision; DA: Decision Aid; Control: no training.

^b Management I concerns clinical application of genomic knowledge with case-based scenarios, and Management II concerns clinical application of genomic knowledge in real practice; subjective/objective concerns how the outcome is measured (through subjective self-assessment vs. through e.g. objective performance on knowledge tests)

initiative called Gen-Equip has recently been set up to promote high-quality genomic education in primary care across national settings [27]. The researchers are currently investigating short- and long-term effects of educational interventions through the comparison of pre- and post-module test scores, a cross-sectional survey to assess usefulness to practice, and user satisfaction of genomic interventions in Europe. Such a collaboration across different countries can help disseminate effective training, increase genomic competency among physicians, and accelerate the appropriate integration of human genome discoveries into healthcare and disease prevention.

Some further limitations of this study need to be considered. Firstly, the small pool and sample size of the studies made it difficult to draw robust conclusions. Secondly, since interventions and the measurements of their effects were heterogeneous, no quantitative meta-analysis was conducted. Moreover, the search was restricted to papers published in English, so there may be relevant studies of educational interventions published in other languages that have not been included. As in all systematic reviews, publication bias might also be an issue, as those studies reporting positive effects are more likely to be published than those with null findings. Finally, among the studies included, there was no clear difference between the outcomes of the randomised and non-randomised trials, nor between studies arising from different countries.

In conclusion, most of the studies in our review of educational interventions reported a positive effect on at least one aspect of genomic competency in non-geneticist MDs, especially in the case of knowledge and confidence components, and subjectively assessed management outcomes. However, future studies considering effectiveness of interventions with a focus on long-term health outcomes across national contexts are recommended.

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