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The Opinions of Medical Faculty Students on the Levels of Genetic Knowledge

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Abstract

Purpose: The aim of this study is to determine the basic genetic knowledge of medical school students and their self-reported knowledge about some genetic defects-diseases and genetic counseling.

Materials and methods: In this descriptive study, data were collected through an online survey. The questionnaire was sent to preclinical and clinical students in semesters 1-6, and 328 students answered the questionnaire.

Results: Of the total 328 students, 59.5% were female and 40.5% were male. The mean age was 21.42±1.99 years and 57.6% of the students were in pre-clinical and 42.4% were in clinical classes. Students in pre-clinical classes reported less knowledge of basic genetics, genetic defects, and diseases when compared with the students in clinical classes ($p<0.05$). Upon examining the responses of the students about giving genetic counseling, the rate of clinical classes was found to be higher ($p<0.05$). Students in both pre-clinical (78.3%) and clinical (89.2%) classes stated that they would like to get more education on genetic diseases and genetic counseling.

Conclusion: In this study, most students were found as having a desire to receive more education and knowledge about genetics and genetic counseling. These findings are believed to guide the review and renewal of current genetic education in medical schools.

Keywords: Genetics; Genetic Education; Genetic Counseling

List of Abbreviations: DNA: Deoxyribonucleic Acid; HGP: Human Genome Project; NIH:National Human Genome Research Institute; UME: Undergraduate-Level Medical Education; WHO:World Health Organization; DS:Down syndrome; SMA1:Spinal Muscular Atrophy Type 1; HD: Huntington's disease; NHGRI: National Human Genome Research Institute; NCHPEG: National Health Coalition for Professional Education in Genetics; ELSI:Ethical, Legal And Social Implications; MBBS Program: Bachelor of Medicine, Bachelor of Surgery; PCPs: Primary Care Physicians; PGx: Pharmacogenetic Testing; FXS: Fragile X Syndrome

Introduction

Advances in genetics and clinical applications have been very rapid due to the technological advances in DNA sequencing and increasing patient data [1]. The entire sequence of the human genome was completed and published as "The Human Genome Project-HGP" in collaboration with the international community in April 2003 [2]. HGP and the National Human Genome Research Institute (NIH) emphasized that competences in preventing diseases through diagnosis and treatment were increasing and many of them would definitely benefit humanity in medical care in the future [3]. Upon assessing the impact of genomics on society, health and biology, Collins et al. [4] found out six basic disciplines to be taken into account including the resources, technological development, computational biology, education, ethics, legal and social contents. They stated that for promoting the individual and the public health, the integration of genomics depends on the interplay of environmental factors and genetics in health and disease, as well as the effective training of the public and health professionals [4]. However, educational efforts to increase the number of geneticists to provide these approaches and apply them clinically cannot meet the need [5, 6]. In order to do this, genomic medicine approaches should be encouraged to be meaningfully adopted by the non-geneticists and medical education should enable physicians to implement these strategies in their field of practice. While some of these educational efforts are specialty-specific, a solid foundation needs to be built primarily in undergraduate-level medical education (UME). To this end, it is important to take into account the trends in relation to genetic education in UME [7]. Kohazaki [8] both discussed the training methods to educate the next generation of students/other health professionals within the medical educational institutions in Japan and proposed suggestions to accelerate the Japanese education and to contribute to genomic medicine around the whole world. In this article, Kohazaki also made reference to the World Health Organization (WHO) publication, noting that regardless of their profession, not only physicians, but all health care providers such as nurses and public health nurses were advised to have the ability to provide genetic counseling. According to WHO [9], the occupational and population ratio of medical geneticists is about 1:220,000 in developed countries and 1:3,700,000 in developing countries and Japan.

Medical genetics affected all medical practices and it was started to be integrated into the clinical curriculum and basic sciences of medical students as well as physician education [10]. de Silva et al. [11] conducted a study to determine the knowledge of medical school students and recent graduate physicians about certain genetic disorders such as Down syndrome (DS), hemophilia (hem), spinal muscular atrophy type 1 (SMA1), and Huntington's disease (HD), and together with them the attitudes toward counseling, the acceptability of prenatal diagnoses, and the termination of pregnancies affected by them. While The National Human Genome Research Institute (NHGRI) suggests that physicians and future physicians need to be trained, The National Health Coalition for Professional Education in Genetics (NCHPEG) has stated that physicians should be educated in the ethical, legal and social implications (ELSI) associated with genetic testing and counseling. In order to meet this need, Metcalf et al. [12] assessed the effects on students' knowledge, attitudes, self-efficacy and intended behaviors by developing an internet-based curriculum to educate medical students about ELSI-related issues in terms of genetic testing and counseling. Bentwich et al. [13], also noted the possible cultural impact in their study of medical students' attitudes about reprogenetics and reproductive risks.

Cargonja et al. [14] also emphasized the need-based education in medical genetics for medical students as indispensable for providing better health care to patients with genetic disorders, increasing the level of knowledge, and developing positive attitudes.

In studies conducted with physicians, the importance of medical genetics education, the effect of genetics in all medical practices, the inability to cite genetic conditions, obtaining detailed family history and appropriate medical genetic information when creating primary care [15,16] were basically emphasized. It is becoming increasingly important for the doctors to fully understand the basic science of human genetics and the ethical, legal, and social implications associated with genetic testing and counseling [12]. Lehmann et al. [17] noted that precision medicine and genetic testing had the potential to advance health care by improving our understanding of diseases, early detection of diseases, and the adaptation of treatments that could improve

health outcomes. However, the responsibility to think carefully about when and how to use this new technology to ensure that ethical practice of precision medicine has appropriate testing were claimed to be paid close attention, together with the systems to assist the interpretation of data and to protect data privacy and security. They also underlined that doctors would need to develop their own genetic literacy through a continuous, lifelong learning approach so that they can engage patients in informed conversations about the relevance, risks and benefits of precision medicine and genetic testing.

Haga et al [18] reported that as the range of drugs in which pharmacogenetic tests became available expands, the primary care physicians (PCPs) were expected to become the primary users of these tests. In a survey conducted to assess the education, familiarity, and attitudes toward pharmacogenetic testing (PGx) in order to identify intake barriers that could be addressed at this early stage of test use, the majority of respondents responded that they heard of PGx testing and predicted that it was, or soon would be, a valuable tool for informing drug response; however, only a small fraction (13%) of respondents reported feeling comfortable requesting PGx tests, and almost a quarter reported having received no training in pharmacogenetics. Li et al [19] conducted a comprehensive analysis of Fragile X syndrome (FXS) using a self-administered questionnaire to investigate the attitudes of Xiangya Medical Faculty students toward genetic testing and counseling issues. The knowledge obtained related to the attitudes of medical students towards these FXS issues in China is of great importance in terms of developing appropriate genetic tests and training FXS consultants. McIlvried et al [20] suggested that advances in the field of genetics and genetic testing would become increasingly relevant to all areas of healthcare; therefore, the importance of increasing genetic education in the education of all physicians, including the medical school curriculum was emphasized. In this study, the knowledge and training needs of medical faculty students, who are future physicians, for some genetic disorders-diseases and genetic counseling with their basic genetic knowledge has been aimed to be determined.

Materials and Methods

Study Design, Setting and Population

It is a descriptive study. It was conducted in a single center. The study was conducted on 328 medical students by collecting online data using non-probability sampling method. Universe is Faculty of Medicine 1st-6th year students (N=1468). No sample selection was made and the survey was sent online to all students. The students were given explanations about the purpose and the content of the research, and they were asked for consent of participation. In the informing consent form, the collected data were promised to be confidential and to be used only in scientific research.

Method of Data Collection

Questionnaire Survey

The data were collected through an online survey between April and June 2021 due to the Corona pandemic. The items in the questionnaire were developed based on relevant articles [21-25] Questions related to genetic counseling were developed based on WHO [26] criteria in a public health study [27]. The questionnaire's validity and reliability were not researched because our goal was not to create a tool.

Students studying in semesters 1-6 responded the questions in the survey which consisted of a total of 58 questions in three sections. While the socio-demographic characteristics of the students were inquired in the first section, in the second one, the questions were on the basic genetic knowledge (16 questions), the knowledge about some genetic disorders-diseases (34 questions), the thoughts about genetic counseling (8 questions), an open-ended question and the hours of genetics lessons that were taken. Tables were created by taking into account the topics on which preclinical and clinical students provided little knowledge.

Data Analysis

Data were analyzed with SPSS 26.0 (IBM SPSS Statistics 26 software (Armonk, NY: IBM Corp.) package program. Constant variables were expressed as mean ± standard deviation, median, minimum-maximum values, and categorical variables as numbers and percentages, and were tested by chi-square, Cramer's V statistical analyses. Tables were created by taking the topics on which the pre-clinical and clinical students expressed little knowledge into account. The probability of error was taken as α=0.05.

Results

59.5% of the students participating in the study were female and 40.5% were male. The mean age arithmetic has been 21.42±1.99 (min-max 18-36). The percentage of 1st, 2nd and 3rd grade students who were in pre-clinical education is 57.6%, and 4th, 5th and 6th grade students who were in clinical education is 42.4% (Table 1).

Table 1: Student's sociodemographic characteristics

	Sciodemographic	**n(%)**
Gender		
	Female	195(59.5)
	Male	133(40.5)
Age groups		
	≤ 20 years	108(32.9)
	21-25 years	211(64.3)
	≥26 years	9(2.7)
	Mean ± SD = 21.42±1.99Min – Max = 18-36	
Grade		
Preclinic	1rd grade	68(20.7)
	2nd grade	51(15.5)
	3rd grade	70(21.3)
Clinic	4th grade	91(27.7)
	5th grade	27(8.2)
	6th grade	21(6.4)

Students in pre-clinical classes stated that they had less basic genetic knowledge when compared with students in clinical classes (p<0.05). Upon the comparison of the basic genetic knowledge of students in pre-clinical and clinical classes, the pre-clinicals stated that they had little knowledge about Recombinant DNA Technology (92.1% / 66.2%), Population genetics (91.0% / 68.3%), Prenatal diagnosis (90.5% / 61.9%), Gene therapy (93.1% / 74.8%), Genetic counseling (92.6% / 72.7%), Genetics and ethics (98.4% / 73.4%) (Table 2).

Table 2: Students' basic genetic knowledge

	Medical Student				
Basic genetic knowledge	**Pre-clinical(n=189)***	**Clinical(n=139)***			
	n(%)	**n(%)**	χ^2	***p***	**Cramer's V**
Mitosis	62(32.8)	25(18.0)	9.025	.003	.166
Meiosis	79(41.8)	29(20.9)	15.896	.001	.220
Nucleic acids (DNA, RNA)	89(47.1)	45(32.4)	7.178	.007	.148
Protein synthesis	97(51.3)	52(37.4)	6.254	.012	.138
Recombinant DNA Technology	174(92.1)	92(66.2)	34.985	.001	.327
Mendel Principles	97(51.3)	48(34.5)	9.155	.002	.167
Single-gene heredity	97(51.3)	49(35.3)	8.375	.004	.160
Multi-gene heredity	122(64.6)	69(49.6)	7.321	.007	.149
Mitochondrial heredity	142(75.1)	80(57.6)	11.315	.001	.186
Human chromosomes and irregularities	147(77.8)	66(47.5)	32.288	.001	.314
Gender-related disorders	139(73.5)	61(43.9)	29.611	.001	.300
Population genetics	172(91.0)	95(68.3)	27.166	.001	.288
Prenatal diagnosis	171(90.5)	86(61.9)	38.642	.001	.343
Gen treatment	176(93.1)	104(74.8)	21.475	.001	.256
Genetics Consultancy	175(92.6)	101(72.7)	23.850	.001	.270
Genetics and ethics	169(89.4)	102(73.4)	14.346	.001	.209

*Column Percent-The ones that express little knowledge of basic genetic information have been denoted.

χ^2: Pearson Chi-Square

Pre-clinical students stated that they had less knowledge of most genetic disorders and diseases in comparison with the students in clinical classes; the difference was statistically significant ($p<0.05$) in Duchenne Muscular Dystrophy (94.2% / 74.1%), Tay-Sachs Disease (96.8% / 87.1%), Huntington's Disease (92.1% / 74.7%), Osteogenesis Imperfecta (94.7% / 79.1%), Brachydactyly (94.7% / 74.8%), Achondroplasia (96.8% / 70.5%), Xeroderma pigmentosum (93.1% / 81.3%), Fragile X (96.3% / 76.3%), Hemacromatosis (95.2% / 71.2%), Neurofibromatosis (97.9% / 72.7%) and Familial Hypercolosteromy (93.1% / 78.4%). The knowledge levels of the students in both groups were found as similar only in terms of Colorblindness, Albinism, Trisomy 21 and Alkaptonuria and the difference was not statistically significant ($p>0.05$) (Table 3).

Table 3: Students' knowledge of certain genetic defects and diseases

	Medical Student				
Genetic defect / Disease	**Pre-clinical (n=189)***	**Clinical (n=139)***			
	n(%)	**n(%)**	χ^2	***p***	**Cramer's V**
Rh factor	120(63.5)	38(27.3)	41.933	.001	.358
Sickle cell anemia	113(59.8)	45(32.4)	24.110	.001	.271

Spina bifida/anencephaly	166(87.8)	90(64.7)	24.908	.001	.276
Cleft lip / palate	162(85.7)	88(63.3)	22.182	.001	.260
Phenylketonuria	153(81.0)	75(54.0)	27.542	.001	.290
Hemophilia	137(72.5)	62(46.8)	22.403	.001	.261
Duchenne muscular dystrophy	178(94.2)	103(74.1)	26.305	.001	.283
Tay-Sachs disease	183(96.8)	121(87.1)	11.285	.001	.185
Huntington disease	174(92.1)	101(74.7)	22.255	.001	.260
Color Blindness	120(63.5)	78(56.1)	1.822	.177	.075
Polidaktili	174(92.1)	88(63.3)	41.201	.001	.354
Klinefelter syndrome	141(74.6)	57(41.0)	37.785	.001	.339
Osteogenesis imperfecta	179(94.7)	110(79.1)	18.539	.001	.238
Turner syndrome	135(71.4)	50(36.0)	40.950	.001	.353
Galactosemic	165(87.3)	90(64.7)	23.546	.001	.268
Thalassemia	149(78.8)	67(48.2)	33.427	.001	.319
Albinism	144(76.2)	101(72.7)	.528	.469	.040
Brachydactyly	179(94.7)	104(74.8)	26.765	.001	.286
Achondroplasia	183(96.8)	98(70.5)	45.204	.001	.371
Trisomy 21	142(75.1)	91(65.5)	3.636	.057	.105
Trisomy 18	161(85.2)	103(74.1)	6.266	.012	.138
Trisomy 13	163(86.2)	101(72.7)	9.407	.002	.169
Alkaptonuria	167(88.4)	117(84.2)	1.209	.272	.061
Xeroderma pigmentosum	176(93.1)	113(81.3)	10.693	.001	.181
Frajil X	182(96.3)	106(76.3)	30.031	.001	.303
Colon cancer	159(84.1)	67(48.2)	48.254	.001	.384
Breast cancer	158(83.6)	57(41.0)	64.337	.001	.443
Hemochromatosis	180(95.2)	99(71.2)	36.351	.001	.333
Cystic fibrosis	172(91.0)	80(57.6)	50.346	.001	.392
Neurofibromatosis	185(97.9)	101(72.7)	45.634	.001	.373
Familial hypercholesterolemia	176(93.1)	109(78.4)	15.203	.001	.215
Type 2 diabetes	132(69.8)	61(43.9)	22.282	.001	.261
Gaucher's disease	183(96.8)	126(90.6)	5.602	.018	.131
Myotonic dystrophy	182(69.3)	118(84.9)	13.341	.001	.202

* Column Percent- Genetic defects and diseases have been shown to express knowledge of little

χ^2: Pearson Chi-Square

When the ideas of the students on giving genetic counseling were reviewed, the ratio of clinical classes was found as particularly higher ($p<0.05$) from that of preclinical classes. The only similar rate was "the ability to identify carriers and to recommend

tests by informing patients and their relatives" (p>0.05). Besides, the students in both pre-clinical (78.3%) and clinical (89.2%) classes expressed their desire to get more education on genetic diseases and genetic counseling (Table 4). When students were asked about the hours of genetics lessons; the answers denoted that 47 students did not take any courses, while 145 students took 1-2 courses in modules and tasks per year.

Table 4: What students think about being able to give genetic counseling

	Medical Student				
Genetic issues	**Pre-clinical (n=189)***	**Clinical (n=139)***			
	n(%)	**n(%)**	χ^2	p	**Cramer's V**
To be able to inform individuals about consanguineous marriages	155(82.0)	128(92.1)	6.896	.009	.145
To be able to inform individuals about issues that require genetic approach, such as risky pregnancies	118(62.4)	126(90.6)	33.466	.001	.319
To be able to inform individuals about common genetic diseases in Turkey and in our region	96(50.8)	87(62.6)	4.519	.034	.117
To be able to identify carriers and recommend tests by informing themselves and their relatives	107(56.6)	87(62.6)	1.184	.277	.060
To be able to learn the genetic history of individuals you suspect to have a genetic defect	109(57.7)	99(71.2)	6.339	.012	.139
Ability to create a family tree	151(79.9)	126(90.6)	7.053	.008	.147
To be able to give information about "Genetic Counseling Centers" in Turkey	39(20.6)	42(30.2)	3.953	.047	.110
Want to be more educated about genetic diseases and genetic counselling	148(78.3)	124(89.2)	6.723	.010	.143

* Column Percent - Those who state that they can give genetic counseling have been shown.

χ^2: Pearson Chi-Square

Discussion

French et al [28], physicians employed at a public medical college were sent a retrospective questionnaire to assess their training in medical genetics and genomics and their level of comfort with ordering genetic testing. In this study, general practitioners were revealed to think that the current medical curriculum did not produce physicians with the necessary competence in medical genetics and genomics. Despite the fact that physicians perceive the importance of this area in medical practice, the need for re-evaluation of medical genetics and genomics education at all levels of education are obvious.

In this study, the aim of which is to analyze the basic genetic information, some genetic disorders-diseases and genetic counseling knowledge of pre-clinical and clinical students of Faculty of Medicine; preclinic students stated that they had less knowledge in all subjects when compared with clinical students. In addition, students in both pre-clinical (78.3%) and clinical (89.2%) classes stated that they wanted to get more education on genetic diseases and genetic counseling. When the answers of the students about being able to give genetic counseling were analyzed, the clinical classes were found as having higher knowl-

edge about "informing individuals about consanguineous marriages (92.1%)", "informing individuals about issues requiring genetic approach such as risky pregnancies (90.6%/)", "learning the genetic history of individuals suspected of having a genetic defect (71.2%), and "creating a family tree (90.6%)"; the difference was also statistically significant. In their studies, in which the training needs of primary care doctors working in Denizli were evaluated in terms of genetics and genetic counseling through a questionnaire, Tomatir et al. [24] found that the highest rate (43.8%) was about chromosomal abnormalities, and the lowest rate (3.8%) was about polygenic inheritance as they examined the response rates to basic genetic information. As the responses of doctors related to some genetic anomalies and diseases were examined, the highest rate was found as 80.0% for xeroderma pigmentosum and the lowest rate was diabetes mellitus with 12.7%. The highest rate of responses to genetic counseling was about sending the at-risk couples or parents to a specialist or genetic counseling center with the rate of 94.8%. The rate of those who know the ethical regulations and techniques related to genetic counseling was 20.7%. In addition, it was stated that 21.1% of them were able to create a family tree by learning the genetic history of individuals with suspected genetic diseases; 22.8% of them were able to organize a screening program for genetic diseases; and 27.3% were aware of the genetic counseling center in Denizli, and 55.4% of them knew about the common genetic diseases in the region. 83.9% of the doctors stated that they wanted to participate in a training program on genetic diseases and genetic counseling. The rates of students and general practitioners who were willing to receive training were similar in both studies.

In another study, Wonkam et al. [29] claimed that in the findings of the survey that included 101 pre-clinical, 95 clinical medical students, and 110 physicians in Cameroon, the awareness of DNA diagnosis was found as poor; sickle cell anemia was 0%, 2.2% and 1.2%, respectively; the majority of respondents considered genetic counseling as indispensable (97.6%, 98.9% and 100.0%); and prenatal diagnosis as acceptable. The acceptance of medical abortion increased with the level of medical education (62.6%, 74.7% and 90.7%). Sickle cell anemia was considered a "serious illness" relative to Down syndrome by most of the participants ($p<0.001$). However, in all three groups, acceptance of termination of the affected pregnancy "if the participant's own child was affected" was lower for sickle cell anemia than for Down syndrome (22.4% vs. 40.2%, 10.8% vs. 29.3%, and 36.1% vs. 70.4%). In conclusion, the data showed that there was insufficient information on genetic testing among medical students and physicians, and they also pointed at the need to promote genetics in Cameroon and develop research on its ethical and social implications. Using a needs assessment and a written exam to assess the genetic knowledge of third- and fourth-year medical students (n=81), Pearl et al. [30] investigated students' own perceptions of basic and clinically relevant genetic principles and clinical skills and their own understanding of the most effective educational methods. Medical students were reported to have greater proficiency in the basic sciences learned in the preclinical years than in clinical concepts, similar to our study and got relatively low levels of knowledge in clinical neurogenetic concepts on examination, with an average of 29% accuracy on questions about genetic counseling and 82% accuracy regarding inheritance patterns (e.g., internet search, family histories). At least half of the students reported having awareness or little understanding of the basic genetics websites (e.g., OMIM) and the support group recommendations and indications for genetic referrals. These results reveal that more specific genetic skills and concepts should be taught and emphasized in the clinical curriculum.

Alotaibi and Cordero [31] assessed the genetic information of 21 medical students to identify and analyze the gaps that formed the basis for the revision of the existing genetics curriculum of the MBBS Program (Bachelor of Medicine, Bachelor of Surgery) of the Princess Nourah bint Abdulrahman University Faculty of Medicine. They stated that the genetic knowledge of medical students was inadequate especially in clinically oriented concepts such as genetic testing and genetic counseling and should be reinforced for the future clinical practices. Since the fourth-year medical students had no genetic knowledge, they reported that it was necessary to integrate medical genetics into the clinical years. A recent study revealed that 75% of USA and Canadian medical faculties provided the genetics content of their education in their first year while only 26% of them provided it at the third and fourth grade [32]. In our study, students reported that genetics education was more in the first year and less in the third and fourth years. This finding is of great importance because the first year is typically filled with limited clinical content and basic science, whereas the third and fourth years are the ones in which most of the clinical learning takes place. For this rea-

son, genetics is referred to as a clinically restricted field of science by keeping the contact with the clinical sciences at its lowest level. This might increase the barriers for the full application of genomic medicine. The fact that genetics was primarily absent at the clinical level of education, the fact that the basic clinical competencies were not developed and the applicability of the field failed to be introduced to non-specialists were reported as a missed opportunity to let the field be more visible [33,34]. Čargonja et al. [14] found that genetics course had a statistically significant effect on the change of students and stated that needs-based education increased not only the knowledge of medical students, but also their self-confidence in maintaining a professional attitude and making the right decisions. In addition, as students learned more, they also realized how important the role of the medical geneticist was for the doctors who were not medical geneticists in the treatment of a patient with the genetic disorder and for the professionals who provided lifelong care to the patient Čargonja et al. [14].

Campion et al [6] noted that advances in technology, reduced testing costs, and increased public awareness led to an increasing demand for genetic services in both clinical and direct-to-consumer areas. For this reason, recent and expected changes in the workforce of genetic counselors and medical geneticists were reported to require a re-examination of the way they trained health care providers and the ways in which they provided access to genetic services. They outlined the rapid growth of genetic and genomic services and the need to consider the various training mechanisms of nurses, assistant physicians and other specialist doctors in order to take advantage of these opportunities, as well as the ongoing training efforts in each of these professions. The World Health Organization also published three guidelines in the Hereditary Diseases Programme [9] and the Human Genetics Programme Part I and II [26,35], respectively.

After all, in order to take the full benefits of genomic medicine, it is clear that the providers of services should be expanded to include non-genetic specialists and primary care physicians, as well [33]. It is apparently understood from the present study that primary care physicians or physician candidates who may work in different specialties whose practices may be affected by genomic medicine in the future need more knowledge and training in genetic and genetic counseling. Taking into account the trends in undergraduate level education, the recommendations of the World Health Organization and the research on genetic education, medical genetics and genomics education should be replanned at all levels of education.

Conclusion and Recommendation

The study concluded that medical students' genetic knowledge is inadequate, particularly with regard to clinically oriented concepts such as genetic diseases and genetic counselling. It was therefore recommended that this knowledge be reinforced in order to better prepare them for future clinical practice. It has been observed that students receive the majority of their genetics content during the initial years of training. While the first year is characterized by a paucity of clinical content and a focus on basic sciences, the third and fourth years witness a reduction in the amount of training provided, coinciding with the period during which the majority of clinical learning occurs. Genetics is thus perceived as a field of science with limited clinical applicability, resulting in a diminished connection with clinical sciences. The notable absence of genetics education in the clinical phase of training, the failure to demonstrate the suitability of the field to non-specialists, and the failure to develop basic clinical competencies are regarded as missed opportunities for enhancing the visibility of the field. This may also serve to increase barriers to the full integration of genomic medicine into clinical practice. It is recommended that awareness about genetic diseases and genetic counselling be increased in medical education, particularly in the third and fourth years of study. It is imperative that physician candidates, who are often required to provide services in the most remote settlements, have access to this information, particularly for the purposes of compulsory service planning. It is not feasible for individuals residing in these regions to access a genetic diagnosis center or a geneticist. It is evident that the full benefits of genomic medicine can only be realized if providers are expanded to include non-genetic specialists and primary care physicians. It is well established that primary care physicians or physician candidates who may work in different specialities and whose practices may be affected by genomic medicine in the future require more information and training on genetics and genetic counselling. Medical genetics and ge-

nomics education should be replanned and increased at all educational levels and in clinical classes during the undergraduate period, taking into account the trends.

Limitations of the study

Some difficulties and limitations were encountered in this study; Students were contacted online due to the Covid outbreak and not all students answered the surveys. From the answers given, it was understood that most of the genetic content was received in the first years of education, and little genetics education was received in the third and fourth years. For this reason, expanding the study by conducting face-to-face surveys with medical faculty students of both the same faculty and other universities may be useful in re-planning education on genetics and genetic diseases.

Ethical Approval

Permission was received for the research from Pamukkale University Ethics Committee. The purpose and content of the research were explained to the students, and their consent for participation was requested. In the informed consent form, it was informed that the introductory information to be collected would be kept confidential and the data would be used only for scientific research.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

No conflict of interest was declared by the authors.

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Author's Contribution

The research was planned by AGT, AÖ and BKV. Statistical analyzes were carried out by BKV. The article was written by AGT. All authors reviewed the article, made necessary corrections and comments, and approved the final version.

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