Medical application usage traits by students in Greece

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Abstract. – OBJECTIVE: Medical applications ("apps") can offer innovative educational capabilities, facilitating the acquisition of learning objectives and enhancing decision making. The present study aims at demonstrating the usage characteristics and relevant perceptions among students in seven medical schools in Greece.

MATERIALS AND METHODS: A descriptive cross-sectional study was conducted through an online survey. Popularity, usage patterns and medical student perceptions regarding medical apps were studied.

RESULTS: A total of 1,458 undergraduate medical students participated, 99.2% owned a smartphone, 72.8% were aware of medical apps' existence, although only 53.9% used them. Apps awareness was higher in higher-ranked universities. Overall, 46% used 1-3 apps, 7.9% more than four apps. 40.3% stated apps' usage at least 1-3 times a month, followed by 16.0% using them 1-3 times per week. Only 2.5% reported daily usage. Students who used more apps tend to use them more frequently. 77.3% used at least half of the downloaded apps. Awareness of medical apps, number of apps in use and frequency of usage tend to increase in each succeeding year of study. The most popular apps and the main reasons of usage are presented in this study.

Current and future perceptions have been investigated. No disparities have been observed between genders.

CONCLUSIONS: Overall medical apps usage was relatively low, despite the high percentage of smartphone ownership. Quantitative traits are enhanced across the progression of medical studies. Utilization frequency is higher in those using more apps. Distinct utilization patterns were identified between preclinical and clinical students, possibly depicting particular needs, portraying apps as a special adjunctive educational tool.

Key Words:
   Education, Apps, Application, Medical, Student.

Introduction

Medical applications (apps) provide medical students with a growing number of specialized tools and resources. Direct and targeted access to updated medical resources could strengthen decision making, thus reducing the number of medical errors. Further potential benefits include enhanced telemedicine capacity, improved communication

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among medical staff, and the possibility of rendering a "learn anywhere" resource. The radical adoption of innovative technological solutions in the last decades has significantly transformed our daily routine and has questioned the conventional educational process. Nowadays, apps are available for all computer devices (desktop, laptop, tablet-pc and smartphones, with the latter having essentially become handheld computers). Interoperability (the ability to transfer content from one platform to another, for instance, from smartphone to laptop through cloud services) has unified the operational capabilities of apps, allowing consistent usage. The expanding, innovative capabilities that apps can offer further suggests their potential role in medical education, which has become more evident during the COVID-19 pandemic[1-3].

Although books traditionally constitute the primary source of knowledge for medical students, the increasing use of mobile devices, including laptops and smartphones, internet availability and the abundance of medical apps, have led a significant percentage of students to use electronic sources of information and interactive media[4,5]. The acquisition of learning objectives in undergraduate medical education is facilitated by a mixture of modalities, including apprenticeship, didactic teaching (lecturing), self-study and small group learning. It is anticipated that some educational approaches prevail, according to individual specific needs and personality type[3]. Students' readiness and willingness to adopt medical apps remain a key factor[6]. Relevant studies[1,2,4,7-14] report overall use rates reaching approximately 80% and positive perceptions towards their educational utility. Moreover, research assessing the impact of medical apps on clinical and academic performance demonstrated that their implementation positively affects medical knowledge and clinical skills, further improving patient care[15-18]. Nevertheless, medical apps assimilation and utilization practices by Greek medical students and their relevant beliefs are mainly unknown.

This study aims at outlining popularity, usage patterns and medical student perceptions regarding the utilization of medical apps among students from seven medical schools in Greece.

Materials and Methods

This descriptive cross-sectional study used an online survey that was provided to medical students in Greece from January 2021 to April 2021. All seven Greek medical schools (National and Kapo-

distrian University of Athens, Aristotle University of Thessaloniki, University of Crete, University of Thessaly, University of Ioannina, University of Patras, Democritus University of Thrace) participated in the study. The survey was distributed through various social media and messenger services to as many medical students as possible. Participation in the survey was voluntary, and students were informed about the purpose. The study was approved by the Ethics Committee of the University of Patras. Informed consent was obtained individually from all participants in the study. There were no exclusion criteria.

Consenting students were asked to complete an online survey provided by a web-based surveying instrument (Google Forms). The questionnaire was composed based on the existing literature[1,7,10,19] and revised by an expert panel for content validity and reliability. The questionnaire consisted of 12 multiple choice questions piloted within the Medical School of Patras and altered appropriately. It is divided into three sections: demographics (gender, age, affiliated university, year of study), apps usage patterns, and relevant perceptions. The questionnaire is available in the ***Appendix***.

Statistical analysis was performed using SPSS software ver. 27.0 (IBM Corp., Armonk, NY, USA). Initial descriptive statistics were undertaken, and inferential analyses were performed using the non-parametric Chi-square test, with the appropriate exact tests. Statistical significance was assumed for $p<0.05$.

Results

1,458 undergraduate students from the seven Medical Schools in Greece participated in the online survey, which corresponds to 17.2% of total medical students in Greece (approximately 8500), 36.4% (n=532) males and 62.6% (n=912) females. The great majority (99.2%) has a smartphone. The main characteristics of the study population are presented in Table I.

72.8% of the participating students from all seven Greek universities was aware of the existence of medical apps. Awareness of medical apps among students ranged from 49.3% (1st year) to 86.8% (6th year), as far as their year of study is concerned, and from 66.3% (University of Patras) to 84.6% (University of Thessaly), regarding their affiliated universities. Moreover, 46.1% of students did not possess any medical app. The rest (53.9%) used one to three apps (46%) or more

Table I. Main characteristics of the study population (N=1,458).

	N (%)
Gender	
Male	532 (36.4)
Female	912 (62.6)
Prefer not to state	14 (1.0)
Age	
18-20	565 (38.8)
21-23	660 (45.3)
24+	233 (16.0)
Year of Study	
1st - 3rd	710 (48.7)
4th - 6th	748 (51.3)
University of	
Athens	271 (18.6)
Thessaloniki	313 (21.5)
Crete	182 (12.5)
Thessaly	117 (8.0)
Ioannina	170 (11.7)
Patras	273 (18.7)
Thrace	117 (8.0)
Missing	15 (1.0)

Table II. Awareness and use of medical apps by year of study and affiliated university.

Awareness*		Use of Medical Apps*		
		0	1-3	4+
Year of Study[1]				
1st	49.3%	68.4%	28.1%	3.5%
2nd	74.8%	43.6%	51.3%	5.1%
3rd	70.2%	51.1%	44.7%	4.3%
4th	72.9%	46.2%	44.7%	9.0%
5th (clinical)	83.1%	36.8%	51.1%	12.1%
6th (clinical)	86.8%	31.8%	56.0%	12.3%
Total	72.8%	46.1%	46.0%	7.9%
University of[2]				
Athens	76.8%	48.2%	44.4%	7.3%
Thessaloniki	71.6%	48.7%	47.9%	3.4%
Crete	76.9%	38.0%	51.3%	10.7%
Thessaly	84.6%	40.2%	51.3%	8.5%
Ioannina	67.1%	52.9%	40.6%	6.5%
Patras	66.3%	37.9%	52.7%	9.3%
Thrace	76.1%	53.8%	38.5%	7.7%
Total	73.1%	46.0%	46.0%	8.0%

1* Chi^2=125.357, $p<0.001$, 1** Chi^2=106.456, $p<0.001$
2* Chi^2=21.561, $p<0.001$, 2** Chi^2=28.762, $p=0.004$

than four apps (7.9%). Awareness of medical apps and the number of apps used per student tended to increase every year of study and were higher in higher-ranked universities, according to QS World University Rankings by subject: Medicine, in 2021[20]. Furthermore, 65.3% of preclinical year students (1st to 4th year) was aware of the existence of medical apps in comparison to 85.2% of clinical year (5th to 6th) students ($p<0.001$). Moreover,

53.6% of the preclinical year students did not use any medical app, while around a third (33.9%) of the clinical year students, $p<0.001$ (Table II), stated that the medical apps were not used.

Regarding the usage frequency, 40.3% of the participants stated that they used medical apps at least 1-3 times a month, followed by a 16.0% using them 1-3 times per week (Table III).

Table III. Frequency of apps use by year of study and affiliated university.

	Everyday	1-3 per week	1-3 per month	Never
Year of Study[1]				
1st	0.3%	13.5%	25.3%	60.8%
2nd	2.1%	17.9%	43.6%	36.3%
3rd	2.1%	11.7%	43.1%	43.1%
4th	1.5%	14.1%	40.2%	44.2%
5th (clinical)	2.6%	15.2%	46.8%	35.5%
6th (clinical)	5.3%	21.4%	45.0%	28.3%
Total	2.5%	16.0%	40.3%	41.2%
University of[2]				
Athens	4.1%	18.8%	39.5%	37.6%
Thessaloniki	1.0%	13.1%	41.2%	44.7%
Crete	1.1%	16.5%	47.3%	35.2%
Thessaly	3.4%	19.7%	41.0%	35.9%
Ioannina	1.8%	11.8%	40.6%	45.9%
Patras	4.4%	17.6%	33.7%	44.3%
Thrace	0.0%	16.2%	46.2%	37.6%
Total	2.4%	16.1%	40.5%	41.0%

[1] $Chi^2 = 91.417$, $p<0.001$
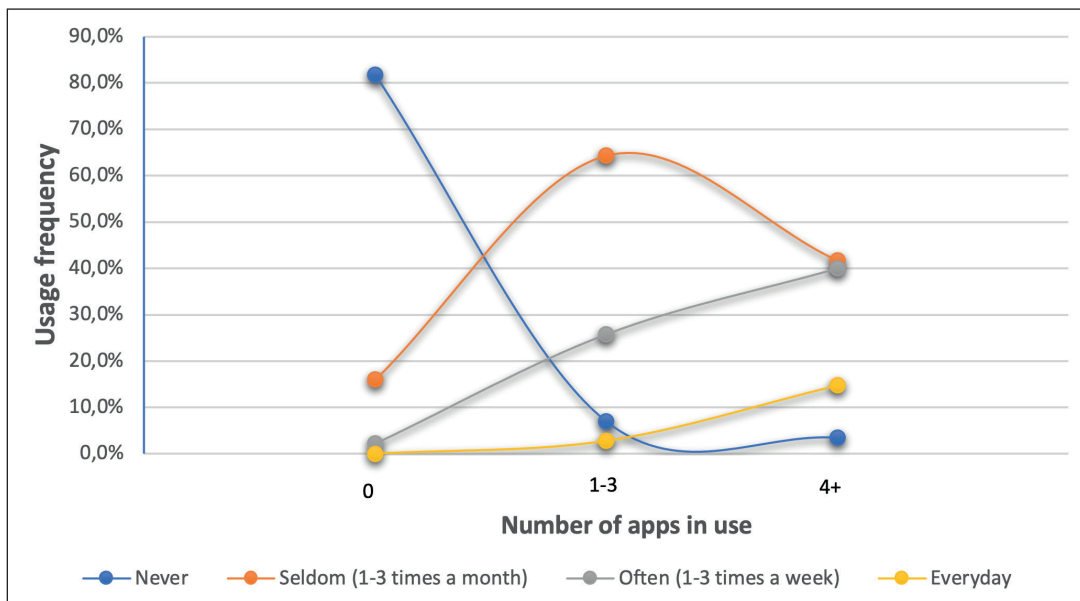[2] $Chi^2 = 33.687$, $p=0.014$

Figure 1. Correlation between the number of apps in use and the frequency of apps usage.

Only 2.5% of the students used their medical apps daily. The apps' usage frequency tends to increase with the progression of studies, while, after pairwise *z*-tests with Bonferroni correction, no differences were found among universities. Students using more apps tended to use them more frequently. Daily peak app usage of students (14.8%) was found in students using four or more apps, followed by 2.8% of students that used 1-3 apps. 40% of students with more than four apps and 25.8% of students with three apps used them regularly (1-3 times a week), while the vast majority of students did not possess any app and had never accessed any medical apps (81.7%) (Figure 1).

The most popular apps are presented in Figure 2. Each participant could provide multiple answers, where applicable. Medscape (35.8%), PubMed (35.3%), Gray's Anatomy-Anatomy At-
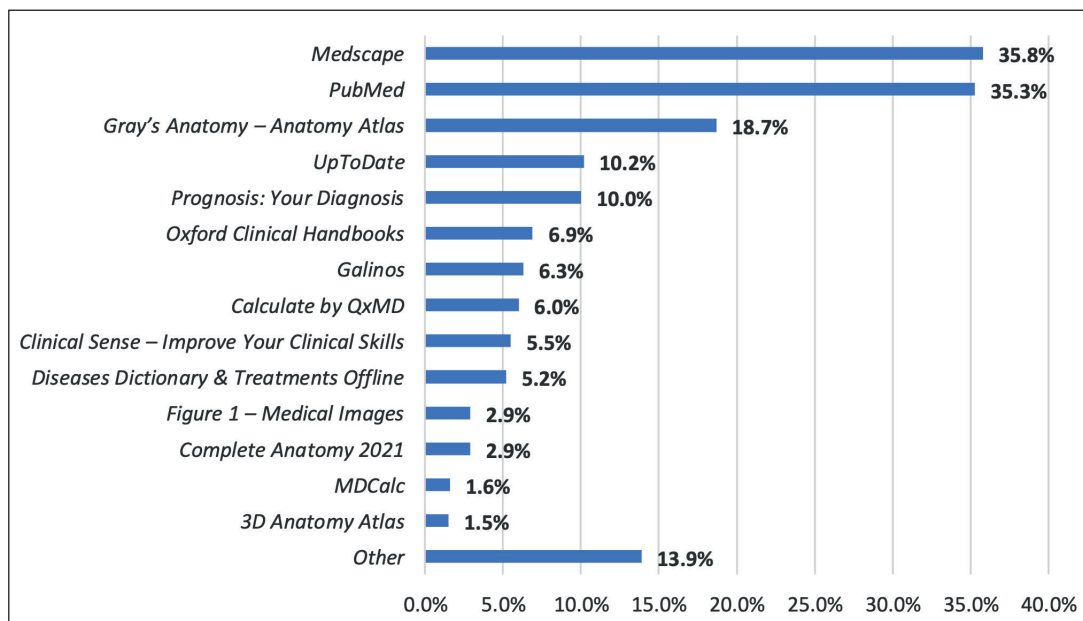

Figure 2. Medical apps' preferences among the study population.

las (18.7%), UpToDate (10.2%) and Prognosis: Your Diagnosis (10.0%) was preferred among Greek medical students. Medscape was mainly favored among students in clinical years, compared to students in preclinical years (48.3% *vs.* 25.4%, respectively), as well as UpToDate (15.1% *vs.* 6.0%, respectively) and Prognosis: Your Diagnosis (13.9% *vs.* 6.8%, respectively), indicated that students, while in clinical rotations, favored apps on diagnostics. Reversely, PubMed (an online medical database) and Gray's Anatomy-Anatomy Atlas were mainly chosen among preclinical students (44.0% *vs.* 24.8% and 28.4% *vs.* 6.9%, respectively). According to every app's description in the online store, the main purposes of apps usage were categorized as follows: disease diagnosis/management (66.9% of all students using apps, 44.5% of preclinical students *vs.* 81.6% of clinical students), medical information/knowledge (50.9%, 55.8% *vs.* 45.0%) and anatomy related (23.6%, 37.2% *vs.* 7.3%). Moreover, regarding the apps' advantages, students stated that the subsequent main reasons of usage constituted the quick reference to medical knowledge (64.4% of students that use apps, 53.0% of preclinical students *vs.* 78.2% of clinical students), medical education and interactive learning (60.6%, 70.0% *vs.* 49.2%), update on medical news (39.1%, 41.2% *vs.* 36.5%), drug reference/guide (21.9%, 10.9% *vs.* 35.2%) and dictionaries/terminology (18.0%, 23.0% *vs.* 11.9%). No differences were found among universities (*p*=0.365). By comparing the apps that students possessed and utilized, it was shown that 77.3% of the students utilized at least half of the downloaded apps.

Overall, medical students' perceptions regarding medical apps are reflected as follows: 44.4% of students stated that medical apps facilitate faster access to clinical medical information, 41.6% would recommend their usage, 26.7% stated that medical apps played an essential role in their medical education, 18.6% reported that they assisted for a reminder of drug references, 17.5% reported apps usage saved time while studying, 15.3% used them to be assisted in making differential diagnoses, while 4.3% preferred not to express any opinion and 1.3% chose the "Other" option. No differences were found among universities (*p*=0.164). Furthermore, the vast majority of students (90.7%) expressed that medical apps usage will increase in the future, while 4.9% believed this would remain stable. Only 0.5% of students believed that app usage would decrease, whereas 3.9% preferred to express no opinion.

No gender disparities were found regarding apps awareness (*p*=0.280), perceptions (*p*=0.057), preferred apps (*p*=0.17), main reasons of usage (*p*=0.308), future beliefs concerning app use (*p*=0.184), frequency of use (*p*=0.059) and smartphone ownership (*p*=0.528). Males used more apps than females (≥4 apps: 5.9% women / 11.1% men, 1 - 3 apps: 46.5% / 45.5%, no apps: 47.7% / 43.4%, respectively – *p*=0.002).

Discussion

According to the findings of this study, assimilation of apps in medical education of Greek students remains relatively low (53.9%), compared to similar studies: 66% of students in a medical school in Australia (2012)[11], 79.8% in East Midlands, UK (2012)[2], 85% in Canada (2012)[9], 37% in Birmingham, UK (2013)[21], 87.5% in Malaysia (2014)[22], 89.1% in Saudi Arabia (2016)[5], 41.5% in Pakistan (2016)[4], 82% in Liverpool, UK (2016)[12], 80% in India (2017)[7], and 56% in Saudi Arabia (2021)[1] use medical apps for educational purposes. These findings suggest a global trend and practice for medical students to own a smart device and utilize medical apps to support their studies and clinical sessions. Highly regarded medical schools in the world – mainly in the United States and in the United Kingdom- have integrated this technological advancement into their medical curriculum, in an attempt to enable physicians to assimilate them into their daily practice, facilitate continuous medical education and directly update the most current evidence-based knowledge[23]. A global trend towards increasing medical apps' usage amongst medical practitioners with less training is expanding steadily. Besides, apps tend to become more focused on a particular function and are user-friendly, resulting in a rapid app usage increase[24]. In this context, it would be plausible to investigate the primary restricting factors and/or possibly the decrease of the promoting dynamics that have emanated from the low integration of apps among medical students in Greece to assist in their educational and career advancement. This study investigated single feasibility restricting factor, ownership of smartphones as the main device operator and found that 99.2% of medical students possessed at least one mobile device. Thus, compromised usage may not rise from unavailable hardware. Instead, academic faculty should play a pivotal role to significantly promote the educational capabilities offered by the relevant software and further encourage their incorporation into medical education.

This study delineated the progressive integration of medical apps used by senior medical students and outlined distinct usage patterns. Awareness of medical apps' existence and the number of apps usage was positively correlated across the advancement of medical studies. A higher number of apps usage were positively correlated with increased usage frequency. Utilization patterns were identified between preclinical and clinical students, possibly depicting their specific needs, rendering apps as a special adjunctive educational tool. Mostly preferred apps, main reasons for use and the overall optimistic aspect of integrating apps in medical education are consistent with previous relevant studies[1,2,5,9-12].

This study assessed the prevalence and perceptions of medical app usage in pregraduate students, varying among residents and doctors. The impact of apps was evaluated via corresponding perceptions, that may be influenced by several factors such as diverging levels of clinical skills, individual competence in apps, apps interface and operation features. Given the study's design, results represent a dynamic situation. On the other hand, an evident strength of this study is the large cohort that encompasses all medical faculties of a specific country and the high response rate, that further reduces the risk of high response and voluntary response bias.

Conclusions

Although student smartphone ownership achieved a high percentage of (99.2%), the overall medical apps usage was relatively low, at 53.9%. Quantitative traits have been improved with the advancement of medical studies. Utilization frequency is higher in students using more applications. Distinct utilization patterns were identified between preclinical and clinical students, possibly revealing their particular needs, rendering apps as a unique adjunctive educational tool.

Ethics Approval

The study protocol was approved by the Research Ethics and Deontology Committee of the University of Patras where the survey was performed (approval No. 7016/18.12.2020). The planning conduct and reporting of human research are in accordance with the Declaration of Helsinki.

Informed Consent

All participants have read an informed consent prior to the completion of the online questionnaire.

Availability of Data and Material

The data that support the findings of this study are available from the corresponding author, [PP], upon reasonable request.

Conflict of Interests

The authors declare that there is no conflict of interest.

Authors' Contributions

Konstantinos Kagkelaris: conceptualization. Konstantinos Kagkelaris, Panagiotis Plotas, George Panayiotakopoulos, Constantinos D. Georgakopoulos, Eleni Jelastopulu: methodology, validation, data analysis and interpretation, visualization. Konstantinos Kagkelaris, Natalia Amasiadi, Andreas Gerakaris, Vasiliki Giorgalla, Panagiotis Efthymiou, Ioanna Efstathiou, Ilias Ziakas, Amalia Katsifara, Christoforos Kitsos, Sokratis Kolios, Ariadni Konstantopoulou, Eleni Kyprioti, Stylianos Mastronikolis, Maria-Myrto Papadopoulou, Nikolaos Razos, Ioannis Schinas, Katerina Skourou: data acquisition. Konstantinos Kagkelaris: writing-original draft. Panagiotis Plotas, Constantinos D. Georgakopoulos, Eleni Jelastopulu: writing – review and editing. Panagiotis Plotas, Eleni Jelastopulu: supervision, project administration. All authors read and approved the final manuscript.

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