

## Use of information and communication technology (ICT) by medical students

*O uso de tecnologias de informação e comunicação por estudantes de medicina*

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### ABSTRACT

**Introduction:** The central topic of the present study is the evaluation of Information and Communication Technology use by medical students, since this relationship has become inseparable from medical training and practice.

**Objective:** To characterize the profile of Information and Communication Technology use among medical students, identifying which are the most frequently used, the possible stimuli and the main impediments to its use.

**Method:** An observational and cross-sectional study was carried out by applying an electronic form on the Google Forms® platform, to students attending from the 1<sup>st</sup> to the 12<sup>th</sup> semester of undergraduate medical school.

**Results:** Of the 216 participants, there was a predominance of females (60.6%), aged between 20-24 years (65.3%) and with a family income of less than 3 minimum wages (36.1%). The main device used by the participants was the smartphone (68.1%) and the most frequently used Information and Communication Technologies were text messaging apps (99.5%) and internet browsers (96.8%), while Medication Apps (48.1%) and Specialized Calculators (31%) were significantly less often used. The main benefit mentioned was the possibility of distance communication, while the main impediment was the issue of security.

**Conclusion:** It was concluded that the use of technologies by medical students is quite frequent and varied, but purposeful training, by teachers and students, is necessary for better use of the available technologies.

**Keywords:** Information and Communication Technologies; Curriculum; Medical Education; Medical students.

### RESUMO

**Introdução:** O tema central deste estudo é a avaliação do uso de tecnologias de informação e comunicação (TIC) pelos discentes do curso de Medicina, uma vez que, nos dias atuais, tal relação tornou-se indissociável da formação e da prática médica.

**Objetivo:** Este estudo teve como objetivo caracterizar o perfil de utilização de TIC entre os acadêmicos, de modo a identificar quais são as mais adotadas, os possíveis estímulos e as principais barreiras ao seu uso.

**Método:** Foi realizado um estudo observacional e transversal por meio da aplicação de um formulário eletrônico, do qual participaram discentes do primeiro ao 12º período da graduação.

**Resultado:** Entre os 216 participantes, notou-se uma predominância do sexo feminino (60,6%), na faixa etária entre 20 e 24 anos (65,3%) e com renda familiar inferior a três salários mínimos (36,1%). O principal dispositivo utilizado pelos participantes foi o smartphone (68,1%). Quanto às TIC, os estudantes apontaram preferência por aplicativos de mensagens de texto (99,5%) e navegadores de internet (96,8%), enquanto aplicativos de medicamentos (48,1%) e calculadoras especializadas (31%) foram significativamente menos utilizados. De acordo com participantes do estudo, a possibilidade de comunicação a distância é o principal benefício das TIC. Com relação aos possíveis problemas, predominou o quesito segurança.

**Conclusão:** O uso das tecnologias pelos acadêmicos é bastante frequente e variado, porém há a necessidade de treinamento deliberado de docentes e discentes para maior aproveitamento das tecnologias disponíveis.

**Palavras-chave:** Tecnologias de Informação e Comunicação; Currículo; Educação Médica; Estudantes de Medicina.

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Chief Editor: Rosiane Viana Zuza Diniz.  
Associate Editor: Jorge Carvalho Guedes.

Received on 05/19/21; Accepted on 08/01/21.

Evaluated by double blind review process.

## INTRODUCTION

The use of Information and Communication Technologies (ICTs) for purposes related to undergraduate school has become increasingly frequent among medical students, either as tools directly linked to teaching or as digital assistants capable of assisting in daily tasks<sup>1</sup>.

Not only that, but the number and variety of available ICTs has also grown in recent years, changing the use profile of these technologies, as well as diversifying the scenarios in which they are used<sup>2,3</sup>.

These modifications occur quickly and cause many doubts regarding the benefits, damages, advantages and disadvantages of using these technologies. However, regardless of any doubts, ICTs are now an inseparable element of medical education, and thus, regulating them and training teachers and students to use them is of great importance<sup>1,2</sup>.

Specifically regarding the use of ICTs in Brazilian medical education, the first steps have already been taken, but more still needs to be done. ICTs are already recognized in the National Curriculum Guidelines (NCG) of the Medical course as essential tools to be mastered during undergraduate school; however, most medical schools are yet to formally include them in their pedagogical projects, leaving the responsibility regarding the regulation of the technology use at the discretion of the current hidden curriculum in each institution<sup>1,4</sup>.

Therefore, this study aimed at characterizing the profile of ICT use among medical students, in addition to identifying possible stimuli and impediments to their use.

## METHOD

This is an analytical, cross-sectional observational study. The study data were collected through an online form, prepared by the researchers themselves, using the Google Forms® platform, and sent to students of the *Faculdade de Medicina e Cirurgia da Universidade Federal do Pará* (UFPA) through text messaging apps, e-mail and social networks, from October 2020 to February 2021. It is worth noting that although the UFPA Medical Course supports the incorporation of new technologies into the educational process, does not have a training program or teacher training in this regard, resulting in its own initiatives and specific approaches by each teacher.

Considering the total number of 914 medical students enrolled at the institution, with a margin of error of 5% or so and a confidence level of 90%, a minimum sample size of 210 students was calculated as significant for this study. A total of 216 students who met the following inclusion criteria were included: 18 years of age or older; being a medical student at UFPA, attending from the first to the twelfth semester of the medical course; be regularly enrolled in the institution.

This study was carried out in accordance with the principles of the Declaration of Helsinki and Resolution n. 466/2012 of the National Health Council, receiving a favorable Opinion from the Research Ethics Committee of the Institute of Health Sciences of UFPA on September 30, 2020, under number 4.311.422 (CAAE 38444020.5.0000.0018).

To analyze and quantify the use of ICTs among the participants, the researchers and the statistician responsible for the study analyses created the Use of Technological Resources (UTR) score. This score analyzes the students' responses to the form and uses the variables "electronic devices to which they have access"; "purpose of the ICT use"; "Most frequently used ICTs"; "Identified impediments to ICT use" and "Identified benefits regarding ICT use" to estimate the degree of use of ICTs in each of the students. Their values range from 1 to 100, and the lower the value, the lower the use of ICTs, and the higher the value, the greater the use of ICTs. To calculate the UTR score, the following formula was applied:

$$URT = ((APS/6 * 100) + (FINS/6 * 100) + (ICTS/12 * 100) + (100 - (BARR/6 * 100)) + (BEN/5 * 100)) / 5$$

URT: Use of Technological Resources

APS: Sum of devices

FINS: Sum of purposes

TICS: Sum of the most often used ICTs

BARR: Sum of impediments

BEN: Sum of benefits

Qualitative variables were presented as the distribution of absolute and relative frequencies and quantitative variables as measures of central tendency and variation. The normality of the variables was assessed using the D'Agostino-Pearson test. The distribution of qualitative variables was assessed using the Chi-square test<sup>5</sup>. Comparisons involving quantitative variables were performed using Student's *t* test and ANOVA with Tukey's post-test<sup>5</sup>, as the variables Age and UTR showed a Gaussian distribution. An alpha error was previously set at 5% to reject the null hypothesis and statistical analysis was performed using the BioEstat software, version 5.3.

## RESULTS

The 216 participants were mostly female (60.6%), predominantly aged between 20 and 24 years (65.3%) (mean age of 23.6±3.7 years) and were mostly from families with an income < 3 minimum wages (36.1%) (Table 1).

The UTR score showed no statistical difference regarding the use of ICTs according to the age group ( $p = 0.5766$ ), gender ( $p = 0.8987$ ) and family income ( $p = 0.0785$ ). However, when analyzing the school semester, a statistically significant

difference was observed regarding the use of these resources ( $p = 0.0179^*$ ) in relation to the first semester, with an URT of 51.0 (significantly lower) and the twelfth semester with an URT of 60.4 (significantly higher) (Table 1).

In the analysis of electronic devices to which the participants have access, it was clear that access to video games and smart TVs is significantly lower than the others, while access to smartphones is significantly higher. Regarding the frequency of use of ICTs, there was a statistically significant trend towards the frequent use of this type of technology (Table 2).

In the analysis of the purpose of using ICTs, it was clear that their use for personal planning is significantly lower than other uses. In the analysis of which ICTs are commonly used, the statistical test showed that the use of specialized calculators and medication apps is significantly lower than the others,

**Table 1.** General characteristics of medical students, related to the URT score.

	N	%	URT	SD	p-value
<b>Age Group</b>					<b>0.5766</b>
Lower than 20	13	6.0	49.8	11.1	
From 20 to 24	141	65.3	55.3	12.1	
From 25 to 29	51	23.6	54.3	10.3	
30 or older	11	5.1	55.0	11.8	
<b>Gender</b>					<b>0.8987</b>
Female	131	60.6	54.4	11.6	
Male	85	39.4	55.3	11.8	
<b>Semester</b>					<b>0.0179*</b>
01 <sup>st</sup>	6	2.8	51.0*	9.0	
02 <sup>nd</sup>	15	6.9	55.2	12.1	
03 <sup>rd</sup>	18	8.3	51.8	9.7	
04 <sup>th</sup>	22	10.2	50.1	11.8	
05 <sup>th</sup>	28	13.0	59.7	11.4	
06 <sup>th</sup>	23	10.6	55.3	12.7	
07 <sup>th</sup>	17	7.9	58.1	8.2	
08 <sup>th</sup>	25	11.6	55.7	12.0	
09 <sup>th</sup>	21	9.7	58.2	13.0	
10 <sup>th</sup>	19	8.8	56.0	7.2	
11 <sup>th</sup>	16	7.4	52.4	12.0	
12 <sup>th</sup>	6	2.8	60.4*	14.2	
<b>Family income (MW)</b>					<b>0.0785</b>
Less than 3 MW	78	36.1	54.0	10.2	
Between 3 and 6 MW	61	28.2	56.4	12.3	
Between 6 and 10 MW	33	15.3	50.8	12.7	
More than 10 MW	44	20.4	56.8	11.6	
Overall	216	100	54.8	11.6	

\* ANOVA, with Tukey's post-test. URT: Use of Technological Resources.

while the use of text messaging apps, internet browsers and reading tools is significantly higher (Table 3).

**Table 2.** Accessed electronic devices and frequency of use by medical students.

	N	%
<b>Electronic device(s) to which they have access</b>		
Smartphone*	147	68.1
Notebook	137	63.4
Desktop	21	9.7
Tablet	20	9.3
Videogame*	1	0.5
Smart TV*	1	0.5
<b>Frequency of ICT use</b>		
Frequently*	184	85.2
Moderately	28	13.0
Rarely	4	1.9

p-value <0.0001\*, Chi-square for adherence, expected equal proportions. ICTs: Information and Communication Technologies.

**Table 3.** Purpose of the use of ICTs and which ICTs are most commonly used by medical students.

	N	%
<b>For what purposes do you usually use ICTs?</b>		
Study	134	62.0
Communication	131	60.6
Leisure	125	57.9
Preparing assignments	124	57.4
Quick Information Check	113	52.3
Personal Planning*	66	30.6
<b>Which ICTs do you normally use?</b>		
Text Messaging Apps*	215	99.5
Internet browsers*	209	96.8
Reading Tools*	209	96.8
Email	205	94.9
Social networks	203	94.0
University Platforms	189	87.5
Clock	178	82.4
Annotation and/or Recording Tools	170	78.7
Calendars and/or Agendas	138	63.9
GPS	120	55.6
Medication and/or Procedure Apps*	104	48.1
Specialized Calculators*	67	31.0

p-value <0.0001\*, Chi-square for adherence, expected equal proportions. ICTs: Information and Communication Technologies. GPS: Global Positioning System.

In the analysis of impediments to ICT use, it was observed that restrictions due to lack of training and lack of internet access are significantly less common than the others, while restrictions due to security reasons are significantly more prevalent than the others. Considering the benefits identified in the use of ICTs, the analysis showed that distance communication is significantly more frequently mentioned than the others (Table 4).

In the analysis of warnings and encouragements to the use of ICTs, the statistical test showed that there is a significant tendency for students not to be warned (73.1%), in addition to a significant tendency for the student to be encouraged (93.1%) (Table 5).

## DISCUSSION

The present study showed that, although the use of ICTs is frequent and even encouraged among students, purposeful training for teachers and students, aiming at the best use of these technologies is necessary, given the little use of important tools in medical practice, such as medication apps and specialized calculators.

**Table 4.** Impediments to the use and benefits identified in the use of ICTs by medical students.

	N	%
<b>Impediments and/or restrictions to the use of ICTs?</b>		
Security*	162	75.0
Distractions	150	69.0
ICT dependence	115	53.2
Device with Appropriate Settings	35	16.2
Internet access*	28	13.0
Lack of training in the use of ICTs*	26	12.0
<b>Identified benefits of using ICTs?</b>		
Distance communication**	208	96.3
Quick Access to Information	207	95.8
Logistic practicality	204	94.4
Democratization of Knowledge	179	82.9
Data management	155	71.8

p-value <0.0001\*, p-value = 0.0234\*\*, Chi-square for adherence, expected equal proportions. ICTs: Information and Communication Technologies.

As in other studies published in the literature, the present research did not identify significant differences in the frequency of ICT use between men and women, or between younger and older individuals<sup>6-9</sup>.

Pereira et. al.<sup>8</sup> even reported in their work a lower use of ICTs among older individuals; however, the analyzed population was different (teachers) and the age variation among the participants was significantly greater, which is why the obtained results must have been discordant

Discrepancies in family income were not statistically relevant either, corroborating the findings that ICT use is quite prevalent in medical education, even in settings with limited resources<sup>10-13</sup>.

As a differential of this study, when analyzing the URT scores between the first and twelfth semesters of the analyzed sample, there was a significant difference in the mean values, *i.e.*, lower and higher, respectively. Such observation, using another methodology, was also made by other authors, such as Ellaway et. al.<sup>14</sup>, who showed in their investigation a lower use of certain ICTs, such as e-mail and digital readers, among students in the first years of undergraduate school.

The explanation for this phenomenon is not clear; however, some points are raised in the literature. The use of ICTs in medical education, as it is not formally regulated in most cases, involves a great degree of student autonomy. However, most students, when starting college/university, do not have a significant mastery of these technologies, consequently failing to use them in different scenarios, whereas students attending more advanced semesters would find situations to use them. It is only with the progress of the course and the effects of the hidden curriculum that these students will start fully using them in their activities<sup>1,14</sup>.

A similar reasoning can also be applied to understand the increased use of ICTs among students attending the twelfth semester. Because these students have already attended practically the entire course, their degree of maturity in relation to the use of ICTs is significantly higher, and they are able to take advantage of these tools without so many reservations or insecurities. However, precisely because they have already experienced almost the entirety of their undergraduate course, these same students are also aware of the gaps in their training. Consequently, as an attempt to remedy deficiencies and reduce

**Table 5.** Warnings and encouragements related to the use of ICTs by medical students.

	Yes	%	No	%	p-value
Have you ever been warned for using them?	58	26.9	158	73.1	<0.001*
Have you been encouraged to use them?	201	93.1	15	6.9	<0.001*

\*Chi-square test for adherence, expected equal proportions. ICTs: Information and Communication Technologies.

insecurities when facing the imminent entry into the labor market, these students use ICTs as complementary training tools<sup>14-16</sup>.

At first, this finding seems to disagree with the study by Rashid-Doubell et. al.<sup>17</sup>, which showed a progressively lower use of ICTs as students advanced in the course, but the aforementioned study focused only on the use of ICTs in clinical contexts, whereas the present study addresses the use of ICTs in different scenarios and situations.

In parallel to the way students use ICTs, it is important to highlight the role of the teacher in this process, who can be a facilitator for a more adequate use of these technologies; however, the most efficient use of these technologies requires significant mobilization by the institution and the teaching staff to incorporate them<sup>18,19</sup>. The lack of adequate teacher training and the compulsory introduction of ICTs in the educational environment can result in considerable frustration for both teachers and students<sup>19,20</sup>.

It was observed that only a small number of students reported having video games and smart TVs and using them as auxiliary learning tools, a fact that is in line with the literature, as both ICTs are not even mentioned in most studies, as they do not have many apps in the health area<sup>2</sup>.

Additionally, there was a significantly high prevalence of smartphone ownership among students, a finding that has also been extensively described by other authors. The reasons for the preference for this device are: portability, internet connection, multiple apps that are useful in the medical and personal area, distance communication, relatively affordable price, when compared to other ICTs, and the fact that they are easy to use, among others<sup>12,16,17,21</sup>.

No statistically significant correlation was observed in relation to tablets, notebooks and desktops, but it is worth mentioning that these devices are widely used in the medical field and can also have several advantages<sup>12,14,17,21</sup>.

When analyzing the frequency of ICT use, the absolute majority of participants reported that they often used these technologies, in addition to feeling quite disadvantaged in their absence. Similar findings are found in the literature and, although some studies do not show such a strong trend towards their frequent use, it is a consensus that these tools are increasingly present in medical education<sup>1,2,14,22,23</sup>.

A possible explanation for the high prevalence of frequent ICT use in the present study is the SARS-CoV-2 pandemic, which occurred concurrently with the study, and the consequent social distancing measures that were implemented, transforming a large part of the undergraduate activities into online dynamics<sup>24,25</sup>.

When analyzing the reasons why the students used ICTs, their use for personal planning was significantly higher when lower

compared to the other items. Surprisingly, the justification for this finding lies in the probable fact that the participants did not understand what "personal planning" meant. Some students contacted the researchers to ask what the personal planning item was, as it was not explained in details in the form. In addition, none of the analyzed studies obtained results similar to those described in the present one.

Regarding the other uses, no statistically relevant correlation was identified, with the findings of a high prevalence of ICT use for leisure, study, communication, preparation of assignments and quick checking of information being in agreement with the literature<sup>6,13,14,26</sup>.

In the analysis of the most often used ICTs, statistical relevance was observed in relation to the use of text messaging apps, suggesting a strong participation of hidden and informal curricula in the academic medical education in the analyzed sample. Moreover, the wide use of internet browsers (search engines) and the use of reading tools (bibliographic repository) are also in line with the literature, as it indicates that the main purpose of using ICTs encompasses a bibliographic repository. On the other hand, the use of special calculators, such as for calculating drug doses, was not an important feature for the participants, which is in contrast with the results of other studies, where this tool occupies a prominent position, mainly as an aid to clinical decision making<sup>2,22,27</sup>.

Regarding the impediments to ICT use identified by the participants, there was a statistical relevance related to restrictions due to security reasons. This finding is probably associated with the fact that the main device used by the students is the smartphone. According to Maudsley et. al.<sup>2</sup>, because the smartphone has a camera, patients may object to its use for ethical reasons, in addition to offering a potential instrument for breach of the doctor-patient confidentiality. Issues related to the physical security of the device (theft, damage, etc.) are also of great relevance when talking about the use of these technologies in developing countries such as Brazil<sup>12,13,28,29</sup>.

On the other hand, the statistical significance of the present study in relation to the minimal restrictions due to lack of training or lack of internet access diverges from that of the literature, as some authors even recommend that there should be more recommendations not on "how" to use these tools, but "when"<sup>1,2</sup>. Moreover, most of the studies analyzed by Mi et. al.<sup>30</sup> indicate that internet connection and access problems constitute impediments that are frequently faced by students.

Among the mentioned benefits with statistical significance, it was observed that distance communication is the main advantage of using ICTs. According to the literature, this benefit is justified by the easy communication with preceptors<sup>14</sup>, in addition to the easy orientation exchange

among the students themselves, as well as the sharing of didactic materials<sup>2,31</sup>.

Regarding the warnings about the use of ICTs, the pattern found in this investigation differs from most of the literature, considering that there was a greater tendency for the student not to be warned, rather than the opposite. Not only that, but in addition to the student not being warned, there is still a tendency to encourage the use of these technologies, a result that is quite different from some other studies that demonstrate greater resistance by the teachers to use these tools during classes or in clinical practice<sup>10,14</sup>.

Among the main limitations of the study, it can be inferred that the platform used in the investigation, Google Forms®, *a priori* excludes people who do not know how to use it, in addition to excluding students who do not have access to the internet. Moreover, with the online questionnaire template, it is not possible to know the actual circumstances in which the questionnaire was answered. That said, this type of data collection also impairs the possibility of a prompter assistance to the participant regarding possible doubts related to a certain item on the form, in addition to making the results subject to questions related to the objectivity.

Also as a limitation of this study, it is pertinent to emphasize that this study was carried out in a single institution, thus showing a more direct picture of the reality observed there; however, the method used and the coherence with other observations in the literature allow us to consider that the results can be extrapolated to other realities or even used in the comparison with similar investigations carried out in other educational institutions.

## FINAL CONSIDERATIONS

This study showed that the use of ICTs by the assessed medical students is quite frequent and varied. Several ICTs that are used by these students, but the most common ones are text messaging apps, internet browsers and reading tools.

As the main stimulus identified for the use of these technologies, communication stands out, either to keep in touch with teachers, friends, family, or simply to share information with other users.

Regarding the identified impediments to the ICT use, the main concern was that related to security, whether physical (theft, robbery, damage, etc.) or digital (data privacy).

Finally, it is concluded that although the use of ICTs is frequent and encouraged among students, the evidence of the scarce use of important resources for medical practice, such as medication apps and specialized calculators, suggests the need for purposeful training, of both teachers and students, aiming at better use of the available technologies.

## ACKNOWLEDGMENTS

To Professor Alex de Assis Santos dos Santos, statistician responsible for the analysis of this study, including the Use of Technological Resources (URT) score, for his excellent work.

## AUTHORS' CONTRIBUTION

José Carlos Gomes Pereira and Lucas Pontes dos Santos: Study conception, collection, analysis and interpretation of data and the writing of the final version of the manuscript. Cezar Augusto Muniz Caldas: Study conception, analysis and interpretation of data, writing of the final version and critical review of the manuscript.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

## SOURCES OF FUNDING

The authors declare no sources of funding.

## REFERENCES

1. Masters K, Ellaway RH, Topps D, Archibald D, Hogue RJ. Mobile technologies in medical education: AMEE Guide n° 105. *Med Teach*. 2016 June 2;38(6):537-49.
2. Maudsley G, Taylor D, Allam O, Garner J, Calinici T, Linkman K. A Best Evidence Medical Education (BEME) systematic review of: what works best for health professions students using mobile (hand-held) devices for educational support on clinical placements? *BEME Guide n° 52*. *Med Teach*. 2019 Feb 1;41(2):125-40.
3. Gordon M, Patricio M, Horne L, Muston A, Alston SR, Pammi M, et al. Developments in medical education in response to the Covid-19 pandemic: a rapid BEME systematic review. *BEME Guide n° 63*. *Med Teach*. 2020;42(11):1202-15.
4. Brasil. Resolução no 3, de 20 de junho de 2014 [access in 28 mar 2021]. Available from: [http://portal.mec.gov.br/index.php?option=com\\_docman&view=download&alias=15874-rces003-14&category\\_slug=junho-2014-pdf&Itemid=30192](http://portal.mec.gov.br/index.php?option=com_docman&view=download&alias=15874-rces003-14&category_slug=junho-2014-pdf&Itemid=30192).
5. Ayres M, Manuel Jr A, Ayres DL, Santos AAS. *Bioestat 5.3 aplicações estatísticas nas áreas das ciências biológicas e médicas*. Belém: IDSM; 2007.
6. Friederichs H, Marschall B, Weissenstein A. Practicing evidence based medicine at the bedside: a randomized controlled pilot study in undergraduate medical students assessing the practicality of tablets, smartphones, and computers in clinical life. *BMC Med Inform Decis Mak*. 2014;14(1):1-5.
7. MacWalter G, McKay J, Bowie P. Utilisation of internet resources for continuing professional development: a cross-sectional survey of general practitioners in Scotland Career choice, professional education and development. *BMC Med Educ*. 2016 Jan 21;16(24):1-9.
8. Pereira TA, Areco KCN, Tarcia RML, Sigulem D. Uso das tecnologias de informação e comunicação por professores da área da saúde da Universidade Federal de São Paulo. *Rev Bras Educ Med*. 2016;40(1):59-66.
9. da Silva JR, de Medeiros FB, de Moura FMS, Bessa WS, Bezerra ELM. Uso das tecnologias de informação e comunicação no curso de Medicina da UFRN. *Rev Bras Educ Med*. 2015;39(4):537-41.
10. Pimmer C, Linxen S, Gröbhel U, Jha AK, Burg G. Mobile learning in resource-constrained environments: a case study of medical education. *Med Teach*. 2013;35(5):1157-65.

11. Pimmer C, Linxen S, Gröhbüel U. Facebook as a learning tool? A case study on the appropriation of social network sites from mobile phones in developing countries. *Br J Educ Technol*. 2012;43(5):726-38.
12. Willemse JJ, Bozalek V. Exploration of the affordances of mobile devices in integrating theory and clinical practice in an undergraduate nursing programme. *Curatationis*. 2015;38(2):1510.
13. Witt RE, Kebaetse MB, Holmes JH, Ryan LQ, Ketsogileng D, Antwi C, et al. The role of tablets in accessing information throughout undergraduate medical education in Botswana. *Int J Med Inform*. 2016 Apr 1;88:71-7.
14. Ellaway RH, Fink P, Graves L, Campbell A. Left to their own devices: medical learners' use of mobile technologies. *Med Teach*. 2014 Feb;36(2):130-8.
15. Kostagiolas PA, Kourouthanassis PE, Martzoukou K, Korfiatis N, Niakas D. Information seeking behavioural paths of physicians for diabetes mellitus care: a qualitative comparative analysis of information needs, sources, and barriers. *Heal Syst*. 2018 Jan 2;7(1):13-28.
16. Nádas M, Bedenbaugh R, Morse M, McMahon GT, Curry CL. A needs and resource assessment of continuing medical education in Haiti. *Ann Glob Heal*. 2015 Mar 1;81(2):248-54.
17. Rashid-Doubell F, Mohamed S, Elmusharaf K, O'Neill CS. A balancing act: a phenomenological exploration of medical students' experiences of using mobile devices in the clinical setting. *BMJ Open*. 2016;6(5):e011896 [access in 28 mar 2021]. Available from: <http://bmjopen.bmj.com/>.
18. Drossel K, Eickelmann B. Teachers' participation in professional development concerning the implementation of new technologies in class: a latent class analysis of teachers and the relationship with the use of computers, ICT self-efficacy and emphasis on teaching ICT skills. *Large-Scale Assess Educ*. 2017;5:19.
19. Pozo-Rico T, Gilar-Corbí R, Izquierdo A, Castejón J-L. Teacher training can make a difference: tools to overcome the impact of Covid-19 on primary schools. An experimental study. *Int J Environ Res Public Health*. 2020;17:8633.
20. Lim CP, Hung D, Wong P, Hu C. The pedagogical design of ICT integration in online learning: a case study. *Int J Instr Med*. 2004;31:37.
21. Davies BS, Rafique J, Vincent TR, Fairclough J, Packer MH, Vincent R, et al. Mobile Medical Education (MoMed) – how mobile information resources contribute to learning for undergraduate clinical students – a mixed methods study. *BMC Med Educ*. 2012;12(1):1-11.
22. Mosa M, Yoo I, Sheets L. A systematic review of healthcare applications for smartphones. *BMC Med Inform Decis Mak*. 2012;12(67):1-31 [access in 28 mar 2021]. Available from: <http://www.biomedcentral.com/1472-6947/12/67>.
23. Payne KFB, Wharrad H, Watts K. Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey. *BMC Med Inform Decis Mak*. 2012 Dec 30;12(1):121 [access in 28 mar 2021]. Available from: <http://bmcmmedinformdecismak.biomedcentral.com/articles/10.1186/1472-6947-12-121>.
24. Moretti-Pires RO, de Campos DA, Tesser Junior ZC, de Oliveira Junior JB, Turatti BO, de Oliveira DC. Pedagogical strategies in medical education to the challenges of Covid-19: scoping review. *Rev Bras Educ Med*. 2021;45(1):e025.
25. Southworth E, Gleason SH. Covid 19: a cause for pause in undergraduate medical education and catalyst for innovation. *HEC Forum*. 2021;33(1-2):125-142. doi: 10.1007/s10730-020-09433-5.
26. Nuss MA, Hill JR, Cervero RM, Gaines JK, Middendorf BF. Real-time use of the iPad by third-year medical students for clinical decision support and learning: a mixed methods study. *J Community Hosp Intern Med Perspect*. 2014;4(4):25184.
27. Lawrence C, Mhlaba T, Stewart KA, Moletsane R, Gaede B, Moshabela M. The hidden curricula of medical education: a scoping review. *Acad Med*. 2018 Apr 1;93(4):648-56.
28. Scott KM, Nerminathan A, Alexander S, Phelps M, Harrison A. Using mobile devices for learning in clinical settings: a mixed-methods study of medical student, physician and patient perspectives. *Br J Educ Technol*. 2015;48(1):176-90.
29. Tran K, Morra D, Lo V, Quan SD, Abrams H, Wu RC. Medical students and personal smartphones in the clinical environment: the impact on confidentiality of personal health information and professionalism. *J Med Internet Res*. 2014;16(5):1-8.
30. Mi M, Wu W, Qiu M, Zhang Y, Wu L, Li J. Use of mobile devices to access resources among health professions students: a systematic review. *Med Ref Serv Q*. 2016;35(1):64-82.
31. Bogossian FE, Kellett SEM, Mason B. The use of tablet PCs to access an electronic portfolio in the clinical setting: a pilot study using undergraduate nursing students. *Nurse Educ Today*. 2009;29(2):246-53.



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