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Use of smartphones and mobile-based educational applications by medical residents in South India

Running Title: Smartphones and mobile apps usage in medical residents

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ABSTRACT:

Background: *Smartphones and mobile-based applications (apps) are widely used now-a-days by medical students and faculty. Their utility and applications can vary widely based on individual needs and practises. Here we aimed to analyse the usage of smartphones and apps by medical residents for their educational purpose.*

Methods: *This descriptive study involved 86 medical undergraduate and postgraduate residents from several institutions in South India. An online survey questionnaire was used to analyse their smartphone and apps usage perceptions and practices.*

Results: *All our participants used smartphones, with majority using android phones (83.7%), since their undergraduate study period. Over 70% residents used their smart phones for medical education purpose, besides personal and professional communications. Around 98% participants felt that smartphones were beneficial as an educational tool or additional resource for their professional upskilling. Multiple medical apps with diverse clinical educational scope were used by all our participants. Our participants were more conversant with apps than the online medical search engines. The frequent purpose of smartphone and apps usage were for taking educational pictures, watching medical video-lectures, and for medical calculations, learning medical skills. Common factors limiting smartphones and apps usage were cost of apps, apps lacking regulatory recognitions and, smaller mobile screens, user distractions.*

Conclusion: *Smartphones and mobile apps are popular, widely used and indispensable tools in the clinical education and practice of medical residents. Newer curricular designs should recognise and include these innovative tools for the progress of medical education.*

Key words: *Smartphones, mobile-based applications, educational tool, medical residents*

INTRODUCTION:

Smartphones and mobile-based applications (apps) are widely used now-a-days by medical students and faculty.[1] Their utility and applications can vary widely based on individual's needs and customary practises.[2] Since the recent COVID-19 pandemic, these digital gadgets and platforms are rapidly emerging as popular and indispensable medical educational tools in the ambit of ever-progressing electronic or internet-based learning (e-learning) and mobile-learning (M-learning).[3] The factors bringing about this change are the technological advancements, extensive availability, accessibility and acceptability by the young medical residents. Added advantages of the mobile learning tools include their low cost when compared to establishing the conventional learning aids and infrastructure, real-time accessibility, flexible options for learning and self-study, versatile utility, updated to current and evidence-based scientific information.[4,5]

Previous studies from across the world showed that the smartphones and apps are effective medical education tools, as they improved the levels of knowledge and skill attainment by the medical students who used these tools.[6] Differences were observed in the type of mobile phone operating system (OS) and apps used, purpose and frequency of usage among the previous study results.[7] Studies also depicted diverse utilitarian benefits of these tools such as taking notes, accessing clinical or disease information, accessing drug information, health parameter or drug dosage calculation, scoring and diagnostic staging according to standard clinical practice guidelines, skills training by simulations, healthcare documentation and so on.[1-4]

On the contrary, there are also reports concluding no significant impact of smartphone usage on medical students' academic performance, with some other studies also reporting other harmful effects of mobile addiction and adverse health outcomes in the medical students.[8,9] Due to such diverse contrasting evidences and lack of such studies conducted in medical residents from our region, we planned to conduct this study in the undergraduate (UG) interns and postgraduate (PG) medical residents, as they are the major workforce of today's public healthcare system and are the future healthcare policy, decision makers. Hence this study aimed to analyse the usage of smartphones and mobile applications by medical residents for the purpose of medical education. The study objectives for the same were to analyse the educational purpose, frequency, perceptions and barriers for using smartphones and mobile applications by medical residents.

MATERIALS AND METHODS:

This cross-sectional descriptive study was conducted in medical undergraduate interns undergoing their Compulsory Rotating Medical Internship (CRMI) and PG residents from various medical educational institutions in South India. The participants were included in the study after obtaining their informed consent. There were 86 participants included by convenience sampling. An online survey questionnaire was used to collect the participants' practices and beliefs with regard to their smartphones and mobile-based apps usage for medical education purpose.

There were totally 20 items including both open and closed items in the study questionnaire, which was shared to participants as google form. The first six questionnaire items were about the participants' general information, followed by fourteen items on their mobile apps and phone usage behaviour. Four of these items were open, while the remaining sixteen items were closed. Some of the closed items were of single best response type, while some were of multiple responses selection type. The items were designed around questions such as type of smartphone used, duration and purpose of smartphone usage, future perspectives on smartphone usage,

perceived role and impact of smartphone usage on medical educational outcomes, limitations of smartphones and mobile apps.

The participants were asked to give the various medical search engines used. The participants were also informed to enlist the installed mobile apps available in their smartphone, along with the frequency and purpose of using these mobile apps mentioned. The learners' frequency of smartphone and mobile apps usage was categorised based on a five-point Likert scale ranging from never, less than once a month or occasionally, more than once a month or sometimes, more than once a week or often, more than once a day or always. The participants' responses for the questionnaire items were expressed as numbers and percentage frequencies.

RESULTS:

There were 45 (52.3%) females of the total 86 study participants. The participants ranged from 22 to 50 years of age, with the mean age of 26.92 $\pm$ 5.64 years. There were 42 (48.8%) CRMIs and 44 (51.2%) PG residents. Most of the PG residents (n = 40, 90.9%) belonged to the clinical disciplines. Of the PG residents, 37 (84.1%) were pursing MD or MS educational program, 4 (9.1%) were pursuing DNB program, while 3 (6.8%) were pursing super-speciality (SS) training. In the participants, 57 (66.3%) and 24 (27.9%) were from private and government medical colleges respectively, while 4 (4.7%) and 1 (1.2%) were from private and government tertiary care teaching hospitals respectively. Of them 81 (94.2%) were from medical institutions in Tamil Nadu, while 4 (4.7%) and 1 (1.2%) were from Pondicherry and Kerala respectively.

All the participants were using smartphones, with 72 (83.7%) using android phones and the rest using iPhones. All of them had been using smartphones over three years, with the mean reported usage of 7.85 $\pm$ 2.78 years. Regarding the perceived impact of smartphones in their medical education, almost 80 (93%) participants considered beneficial roles, while 4 (4.7%) and 2 (2.3%) participants considered negative and no roles respectively. With respect to the perceived role of smartphone in their medical education and up-skilling, 36 (41.9%) and 48 (55.8%) considered as primary educational tool and additional resource respectively, while 2 (2.3%) participants considered no role. Of the participants 'perceived future usage of smartphones, 55 (64%) still considered using as personal devices, while 31 (36%) considered the usage as educational tools.

The smartphone usage purpose of the participants was primary for personal communication (87.2%), followed by professional communication (73.3%) and then medical education (70.9%) (Figure 1). The three most frequently reported smartphone usage as educational tool were for taking educational pictures, watching medical videos/lectures online and reading e-books (Figure 2). The top three informed limitations of smartphone usage as educational tool were unwanted distractions, small screen size, limited functionality (Figure 3). Almost 52 participants (60.5%) reported of not using specific medical search engines in their smartphones or rather used general search engines like Google, Chrome, Safari, Bing, while few of them reported using medical search engines like Medscape (18.6%), PubMed (14%), WebMD (2.3%) and UpToDate (2.3%).

The mobile-based apps commonly used by the participants included competitive entrance preparation apps like Marrow or PrepLadder (45.3%), medical information apps for continuing professional development (CPD) and evidence based clinical decisions like Medscape or UpToDate or DailyRounds or India Drug Index (26.7%), speciality based networking and clinical calculators like OB wheel, Ped(z), Pediatric Oncall (4.7%) (Figure 4). The three most frequently reported mobile-based apps usage as educational tool were for medical calculations, learning medical skills and watching medical videos/lectures online (Figure 5). The top three informed

limitations of mobile-based apps usage were cost involved for subscriptions, lack of recognition by faculty or institutions or regulators, inadequate service and updates from app developers (Figure 6).

DISCUSSION:

The demographic data of our study participants showed almost equal gender distribution, with a wider range of age group due to their different stages in medical education from UG (CRMI) to PG levels including super-speciality residents. The CRMIs and PG residents were almost equal in distribution. The PG residents were mostly form the masters programs in diverse disciplines, with few of them from other diploma and SS programs. The median and interquartile ranges of participants' age distribution were 25 (23, 29) years. Hence we could observe a sort of balanced baseline distribution of the participants in terms of gender, age and stage of medical education. There was a lack of previous such reports in UG and PG medical residents on smartphones and mobile apps usage from our region.

The majority of our participants were using android phones (83.7%), and all had been using their smartphones for over three years. Though the purpose of smartphone usage was predominantly for personal communication, over 70% reported using them for their medical curricular work such as professional communication to peers or faculty, and educational scope (Figure 1). The commonly reported smartphone usage purposes in the order of decreasing frequency were for taking educational pictures, watching medical videos/lectures online, reading e-books, reading medical news, reading scientific research journals and taking notes (Figure 2).

On the whole, the participants' perceptions on smartphone usage were positive, with almost 93% considering beneficial. Most of them (97.7%) recognised the definitive role of smartphones in their medical education and up-skilling either as a primary educational tool or as an additional learning resource. But owing to some negative influences and limiting factors challenging their current usage practices, majority of the participants (64%) considered using smartphones as personal devices rather than as educational tools in future. Some of the limiting factors on smartphone usage reported by the participants were unwanted distractions, small screen size, limited functionality than laptops or desktop computers, cost of smartphones, privacy concerns and technical difficulties (Figure 3).

The predominant mobile apps used by the participants were those related to competitive entrance exam preparation, by the CRMIs and PG residents aspiring to get enrolled into higher levels of masters or SS programs for their professional specialisation. This was followed by other apps useful in residents' CPD, quick access to medical information, evidence based clinical practice, clinical calculations of medical scores or stages in patients, and medical speciality networking (Figure 4). The purpose of mobile apps usage in the order of decreasing frequency reported were medical calculations, learning medical skills, watching medical videos or lectures online, reading e-books, reading medical news and taking notes (Figure 5).

The frequency and purpose patterns of mobile apps usage were similar to that of our participants 'smartphone usage, thus indicating the predominance of apps usage by our medical residents, owing to the better user comfort and functionality of mobile apps developed exclusively for smartphones over the internet search engines. For this reason we could also observe the lesser familiarity and preference of medical search engine usage in our residents. Despite such increased reported mobile apps usage and benefits, our residents also were concerned with the limiting factors hindering their apps usage such as lack of recognition by faculty or institutions or regulators, cost involved for subscriptions or app-related purchases, inadequate service or updates from app

developers, lack of awareness of the available useful medical apps, privacy concerns and technical difficulties (Figure 6).

Similar smartphone and mobile apps usage practices and preferences were reported in many previous studies conducted in medical students.[1,2,10-12] There were limited such instances reported in the recent past and during the concurrent timeline of our study, involving medical interns or CRMIs, PG and SS residents.[3,13,14] The diverse array of the mobile apps used were in line with the medical educational needs fit to different levels and phases of medical education of our participants. This shows the highly benefitted medical resident participants and henceforth their positive perceptions and attitudes towards smartphone medical apps usage. Though the benefits of such smartphone apps usage were not measured in terms of any learner educational outcomes, they were reported as participants' perceptions in our study.

The previously reported educational benefits of smartphone medical apps usage were improved knowledge and skills learning outcomes in learners of different medical and health professional educational programs across different countries, in a systemic review with meta-analysis.[6] Other reported benefits of smartphone medical apps were increased self-directed learning (SDL) during pandemic lockdown, opportunity for self-learning beyond classroom teaching, quick access to learning resources at the clinical point-of-care, clinical documentation, clinical and surgical skills training, faculty or peer communication and educational resource sharing, access up-to-date research evidences and clinical guidelines, disease staging and scoring, clinical calculations, faster task or assignment or logbook completion, reading e-books and listening to audible books.[1-5,14-16]

Smartphone and app-based learning were considered as a part of M-learning or the broader spectrum of e-learning.[17] These were highly useful for continued learning even in less resourceful setting, for taking field notes and research recordings.[18] M-learning was attempted for improving deep learning approaches with limited utility, but they did correlate with increased levels of visual learners, thus suggesting needs for more pedagogic visual representations for these learners.[19,20] Here we could also infer the greater appeal to wider learner types with the M-learning using smartphones and mobile apps. The self-reported usage, purpose, frequency and limitations of smartphones and apps in our results were similar to the previous studies involving medical students from phase-I to CRMIs and PG residents.[1-3,7,8,13,14]

This wider awareness and usage of smartphones and medical apps among medical students right from the first year calls for the regulatory norms, institutional and faculty acceptance, quality assurance and accreditation practices to improved the standard of these M-learning tools.[4,11,16,17] The limiting factors on these M-learning tools were the cost of smartphones and apps purchase, lack of services and updates. Limitations similar to those expressed by our participants and additional concerns such as the availability of smartphones, internet access, and questionable reliability of the information available online were the issues reported in earlier studies.[2,4,7,21] There were also reports of decreased learner utility performance despite their higher motivation levels for the M-learning modules conducted previously.[19]

While most previous studies reported positive attitudes of learners towards assessment performance, learners in some studies did not show specific assessment improvements or rather showed deteriorating academic outcomes due to the negative impact of smartphone misuse.[6,8,9,14] There were also reports of perceived decline in the importance of clinical patient contact with increased students' M-learning.[22] Other learner disadvantages of using smartphones and mobile apps were unwanted distractions, smartphone addictions besides addiction to

social media or gaming apps, increased stress, disturbed sleep, behavioural disorders, poor learning concentration, obesity, depression, refractive errors, computer vision syndrome, dry eye disease, headache, impaired mindfulness.[9,23,24] Alarming rates of smartphone addiction were reported among medical students and PG residents in recent studies conducted across different parts of India, which on long run could lead on to the above complications.[9,25,26] So cautious use of smartphone and mobile apps is warranted with daily set limits of screen time, although they were intended to be used for educational purpose.

CONCLUSION:

The very high usage rates, positive attitudes and perceptions of our participating CRMIs and PG residents towards smartphone and mobile apps indicate that these evolving e-learning tools have become vital for the medical residents 'day-to-day clinical learning and practice. Hence it is recommended to integrate these M-learning elements using smartphones and mobile-based apps into the medical UG and PG curricula, after quality assurance and with periodic regulatory monitoring to maintain the minimum desired levels of standard, with the combine action of regulatory bodies, medical institutions and faculty. In this way, we would be able to provide for the much needed learner support and guidance in the M-learning aspect and further educational progress of our medical residents on par with international standards in this digital era.

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CONFLICT OF INTEREST: The authors declare no conflict of interest.

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FIGURES:

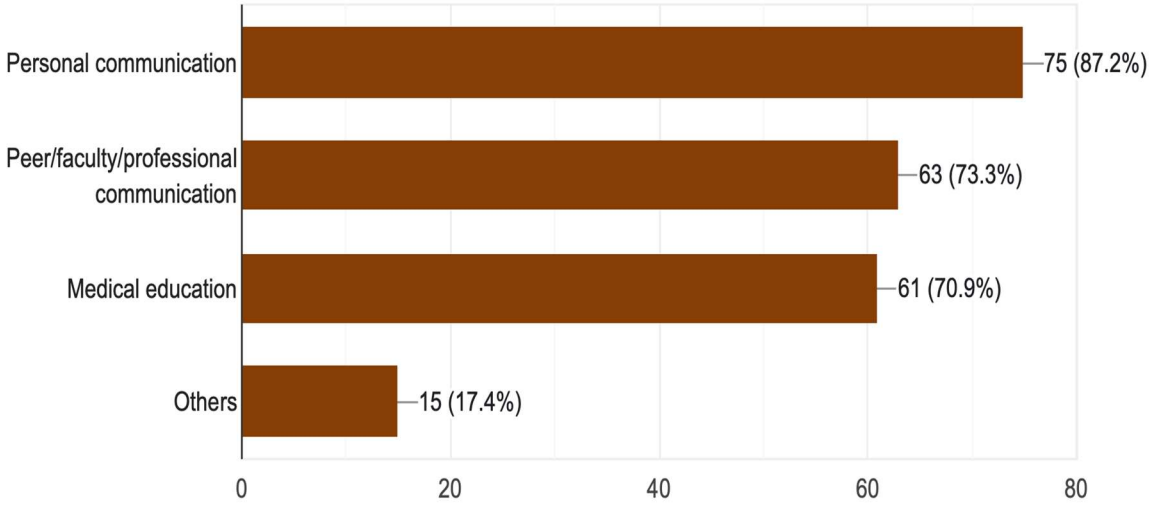


Figure 1 - Major purpose of smartphone usage in participants (n = 86)

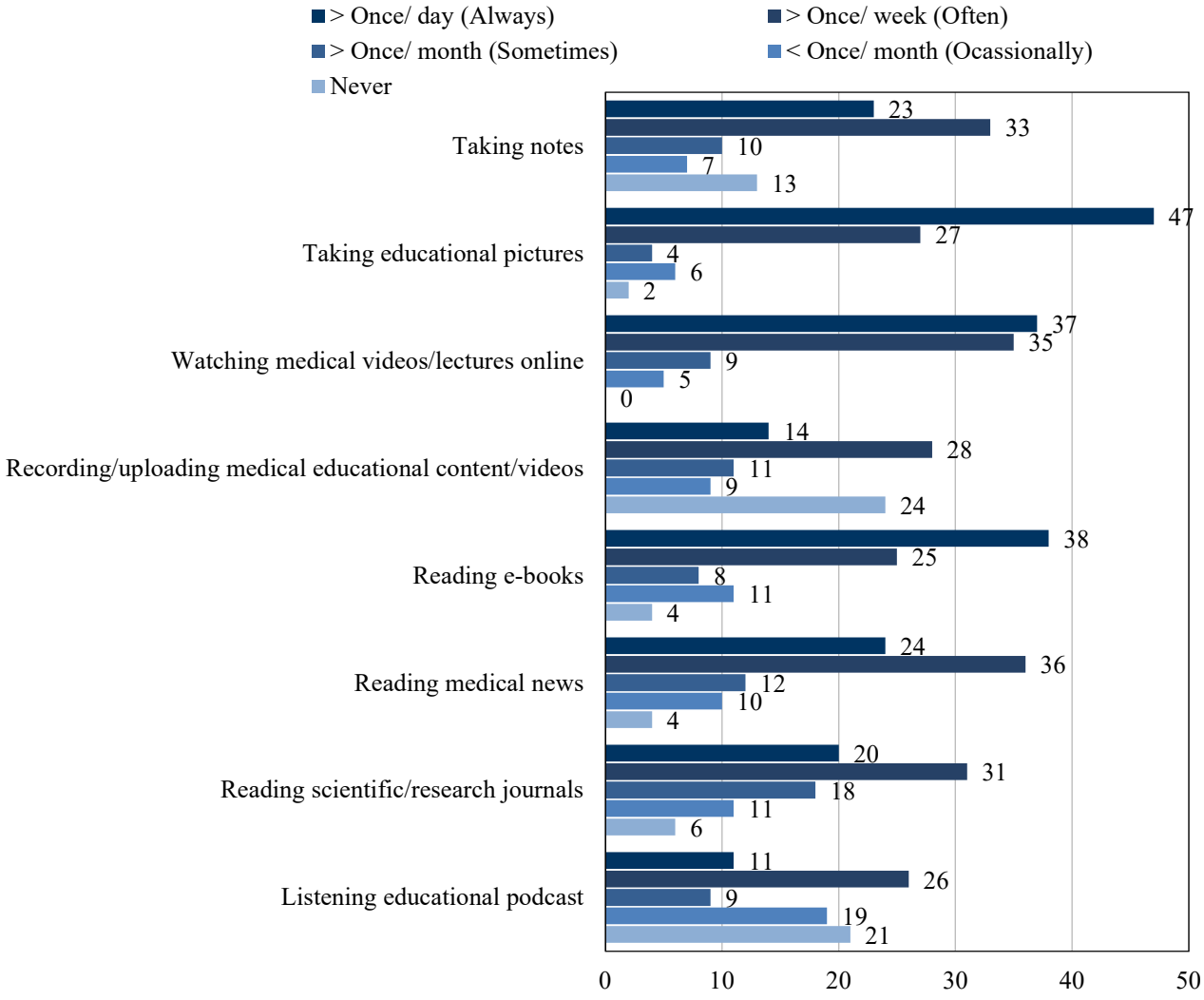
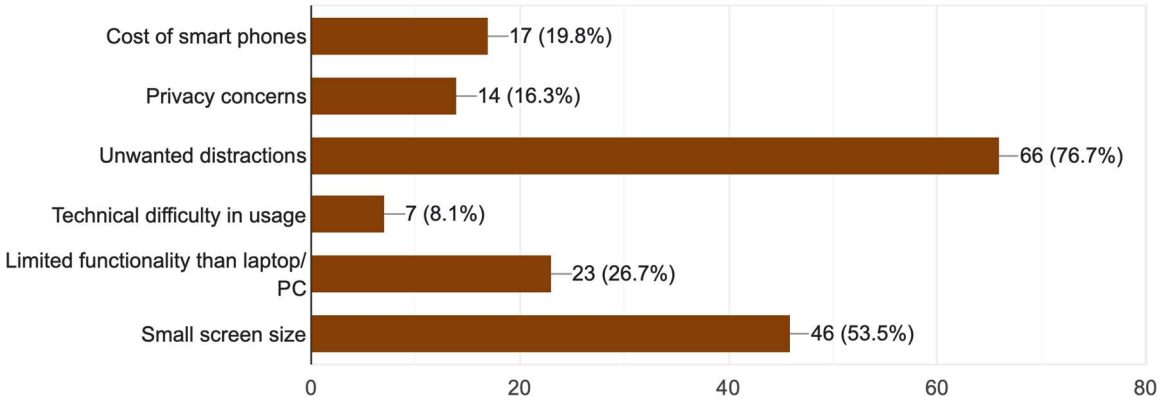


Figure 2 - Purpose and frequency of smartphone usage as educational tool



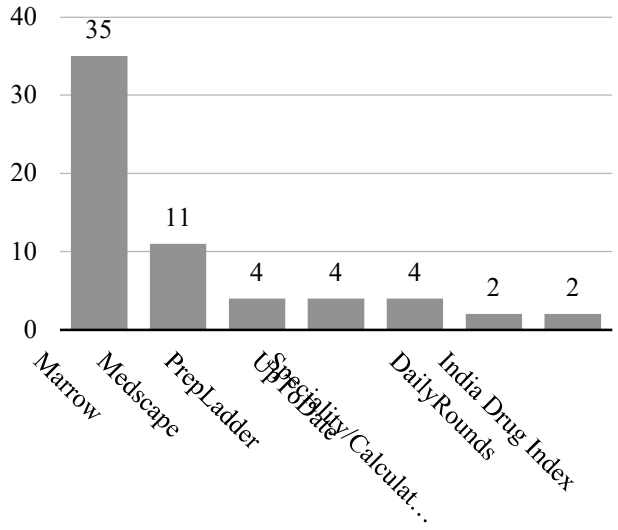


Figure 4 - Mobile-based apps commonly used

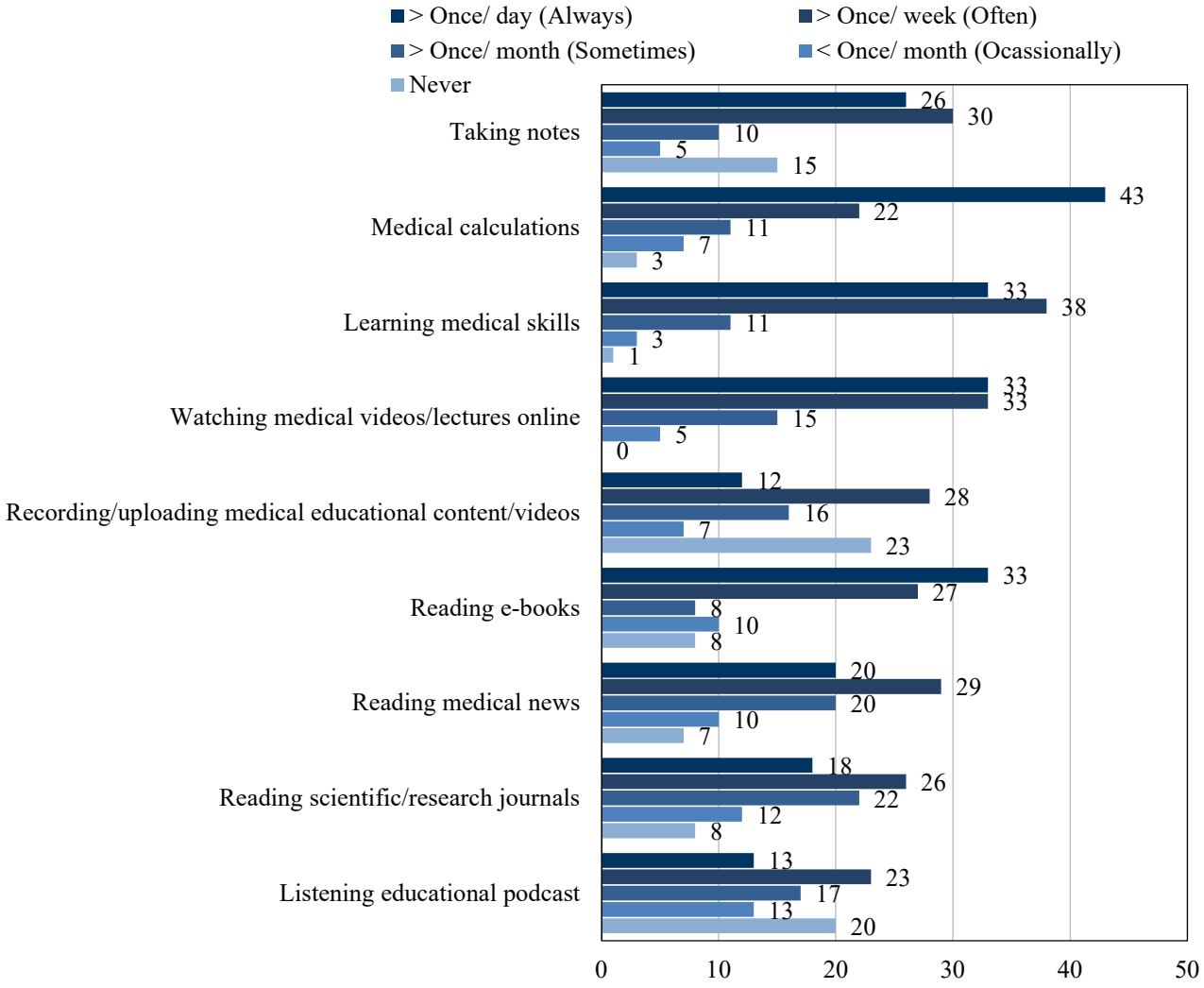
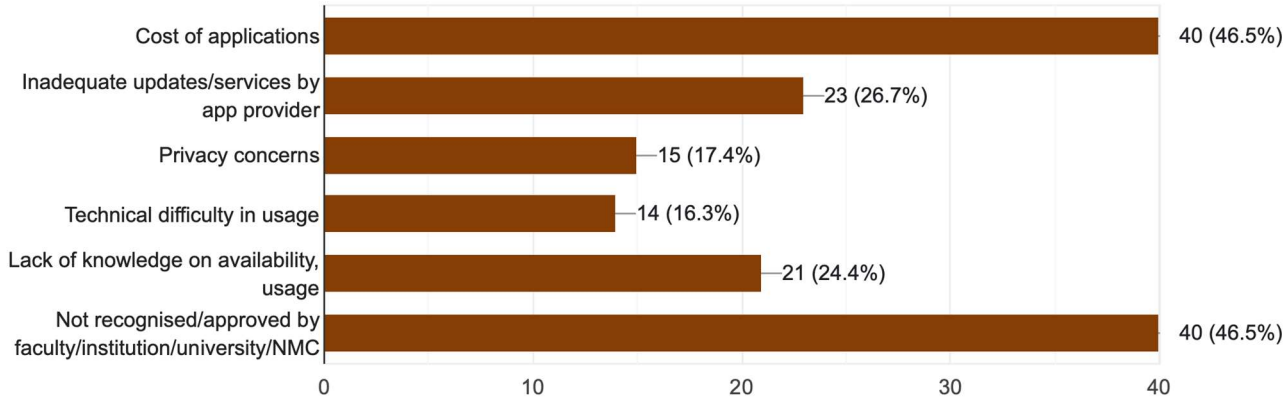


Figure 5 - Purpose and frequency of mobile-based apps usage as educational tool


Cost of applications
40 (46.5%)
Inadequate updates/services by app provider
23 (26.7%)
Privacy concerns
15 (17.4%)
Technical difficulty in usage
14 (16.3%)
Lack of knowledge on availability, usage
21 (24.4%)
Not recognised/approved by faculty/institution/university/NMC
40 (46.5%)
0
10
20
30
40