ORIGINAL ARTICLE

The ownership and clinical use of smartphones by doctors and nurses in the UK: a multicentre survey study

Mohammad H Mobasheri,1 Dominic King,2 Maximilian Johnston,2 Sanjay Gautama,3 Sanjay Purkayastha,1 Ara Darzi2

ABSTRACT
Background Much interest has arisen around the use of smartphones, tablet devices and related apps in the healthcare context. It has been suggested that increasing numbers of healthcare professionals are using these technologies in the workplace. We have performed an up-to-date UK-based, multicentre, cross-sectional survey study exploring the ownership rates and uses of these technologies among doctors and nurses, specifically focusing on the clinical environment.

Methods After initial piloting, all doctors (n=2107) and nurses (n=4069) at 5 hospital sites were invited to complete a 36-item (nurses) or 38-item (doctors) survey. Exploratory descriptive statistics were calculated and the χ2 test was used to compare differences in categorical data between groups. Statistical significance was taken at a level of p<0.05.

Results 98.9% of doctors and 95.1% of nurses owned a smartphone, while 73.5% and 64.7% owned a tablet device, respectively. Also, 92.6% of the doctors and 53.2% of nurses found their smartphone to be ‘very useful’ or ‘useful’ in helping them to perform their clinical duties, while 89.6% of doctors and 67.1% of nurses owning medical apps were using these as part of their clinical practice. Doctors and nurses were using short-message-script messaging (64.7% and 13.8%, respectively), app-based messaging (33.1% and 5.7%), and picture messaging (46.0% and 7.4%) (p=0.0001 for all modalities) to send patient-related clinical information to their colleagues. Therefore, 71.6% of doctors and 37.2% of nurses wanted a secure means of sending such information.

Conclusions Compared to earlier studies, we have demonstrated much higher smartphone ownership among doctors and nurses, who perceive these devices to be useful when performing their clinical duties. Large numbers of staff are sending patient related clinical information using smartphone messaging modalities. Care must be taken by doctors and nurses to ensure that no identifiable patient data is transmitted in this way, and healthcare organisations must develop strategies and policies to support the safe and secure use of these technologies by front-line staff.

INTRODUCTION
Since the release of the earliest commercially available handsets in 1983, mobile phone technology has evolved at an unprecedented rate.1 Miniaturisation coupled with advances in sensors, batteries and computing technologies heralded the release of the first set of smartphones in 2007 and tablet computers a year later. Both devices are capable of running stand-alone software applications referred to as apps. This has elevated the roles of these devices far beyond simple telephonic communication.2

Seventy-two per cent of the UK population now owns a smartphone and 23% own a tablet computer.3 In the USA, ownership rates are 65% and 48%, respectively.4 These technologies have revolutionised the ways that ordinary citizens live their lives, but much interest has also arisen around their use in the healthcare industry. Mobile health (mHealth) is defined as the delivery of healthcare through the use of portable communication devices.5 There are currently >90 000 mHealth apps available and it is predicted that by 2017, 3.4 billion people worldwide will own a smartphone and half will be using mHealth apps.6

A large proportion of such apps are targeted at the lay users and promote healthy living or empower patients to

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manage disease conditions; there are, however, also
an increasing number of apps designed specifically for
healthcare professional use in the clinical environment
to enhance efficiency around work-related tasks.

The unparalleled ubiquity, portability and connect-
ivity of mobile communication devices help healthcare
professionals to access health-related content at almost
any time and place.7 Trusted healthcare organisations,
such as the National Institute for Health and Care
Excellence (NICE) in the UK, have made many of
their guidelines for doctors available in app form to
facilitate decision-making.8 Despite the enthusiasm for
digital health there are pitfalls and several studies have
demonstrated the potential for certain apps to cause
patient harm.9–11 Furthermore, the use of mobile
devices in the clinical arena poses specific security and
privacy challenges12 that must be addressed in order
to mitigate the risks of inadvertently breaching highly
sensitive and confidential patient-identifiable data.

Healthcare organisations are increasingly looking at
strategies and guidance on how smartphones and
tables can be used to enhance healthcare delivery, but
there is scant reliable evidence on the prevalence and
modes of current use. The aim of this study was to
perform an up-to-date prospective survey of doctors
and nurses at a large London-based National Health
Service (NHS) Trust so as to explore the ways that
front-line staff are using smartphones, tablet devices
and mHealth apps in the clinical environment.

METHODS

Study design
A cross-sectional survey study was conducted. The
study was a service evaluation and so formal ethical
approval was not sought or required.

Participants
The study was performed at a large London-based
NHS Trust consisting of five individual hospital sites.
All doctors (n=2107) and nurses (n=4069) employed
by the NHS Trust were invited to participate.

Measures
Electronic surveys were constructed using an online
survey-building tool (Qualtrics). A list of relevant
categories and questions was generated by reviewing
previously published surveys exploring smartphone
and medical app use in similar populations.13–16
Inclusion of categories and questions into the con-
structed survey was through a process of debate and
consensus among the research team. The survey was
piloted in paper form with a small sample of doctors
and nurses independent of the study cohort, to ensure
face validity. In response to feedback, several iterations
of the survey were produced to ensure appropriate
wording and content.

The final nurse survey consisted of 36 items, and
the doctor survey was composed of 38 items (doctors
were asked additional questions regarding the ‘pre-
scription’ of medical apps to their patients). Items
were divided into six main categories; (1) demo-
graphics (5 items), (2) tablet device ownership (4 items), (3)
smartphone ownership (3 items), (4) smartphone use
in the workplace (9 items), (5) medical app ownership
and use in the workplace (14 items) and (6) other
(3 items). A mixture of question types were utilised,
including dichotomous, nominal polytomous, ordinal
polytomous (predominantly 5-point Likert scales) and
open-ended questions.

Distribution process
Prior to distribution, surveys were reviewed by the
NHS Trust’s information governance and information
technology (IT) teams for approval. The email
addresses of all doctors and nurses employed by the
Trust were obtained from the organisation’s govern-
ance department. An email invitation to complete the
survey was sent to each staff member at the start of
January 2015, followed by three reminder emails sent
at 3–4 week’s intervals, thereafter. The survey was
closed on the 31 March 2015, and the results of any
partially completed responses were recorded at this
stage. All survey responses were entirely anonymised.

Statistical analyses
Data were analysed using SPSS for Mac (V22,
Chicago, Illinois, USA) and Graphpad QuickCalcs
(San Diego, California, USA). Exploratory descriptive
statistics were calculated for relevant survey items. The
χ² test was used to compare differences in categor-
egoal data between the doctor and nurse groups.
Statistical significance was taken at a level of p<0.05.

RESULTS

Response rates
Email invitations were sent to 2107 doctors and 4069
nurses. Four hundred and sixty doctors (21.8%) opened
the email invitation and 287 of them (62.4%) completed
the survey, either partially (n=38) or com-
pletely (n=249). Seven hundred and ten nurses
(17.4%) opened the invitation email, and 564 of
them (79.4%) completed the survey (partial n=95,
complete n=469).

Demographics
Respondent demographics are shown in table 1.

Smartphone and tablet ownership
In the doctor group, 98.9% (n=281/284) and 73.5%
(n=211/287) owned a smartphone and tablet device,
respectively, while the corresponding figures in the
nurse group were 95.1% (n=528/555) and 64.7%
(n=363/561), respectively. Ownership of both smart-
phones (p=0.005) and tablet devices (p=0.009) was
significantly higher among doctors. The iPhone was
the most commonly owned smartphone handset in
both groups (doctors 75.6%, nurses 58.4%) followed by Android-based handsets (doctors 21.5%, nurses 41.6%). In the case of tablets, the iPad and iPad mini were the most commonly owned platforms (doctors 83.7%, nurses 76.7%) followed by Android-based devices (doctors 12.0%, nurses 23.8%).

Smartphone use at work

When asked how useful they find their smartphone in helping them to perform their day-to-day clinical duties, 92.6% (n=252/272) of doctors and 53.2% (n=271/509) of nurses stated ‘very useful’ or ‘useful’, and this difference was significant (p=0.0001). **Figure 1** shows the various features of smartphones that staff were using in this regard.

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<th>Age (years)</th>
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Gender

- Male: 111 physicians, 144 nurses
- Female: 453 physicians, 143 nurses

Specialty

- Medical nurse: 132 physicians, 92 nurses
- Surgical nurse: 57 physicians, 53 nurses
- ITU nurse: 49 physicians, 34 nurses
- Theatre nurse: 35 physicians, 22 nurses
- A&E nurse: 31 physicians, 20 nurses
- Paediatric nurse: 28 physicians, 16 nurses
- O&G nurse: 28 physicians, 14 nurses
- Midwife: 14 physicians, 11 nurses
- Recovery nurse: 13 physicians, 7 nurses
- Renal dialysis nurse: 13 physicians, 6 nurses
- Psychiatry nurse: 2 physicians, 14 nurses
- Other: 162 physicians

Level of training

- FY1: 53 physicians, 8 nurses
- FY2: 61 physicians, 17 nurses
- Core training: 7 physicians, 28 nurses
- Registrar: 193 physicians, 106 nurses
- Consultant: 156 physicians, 128 nurses
- Other: 56 physicians, 2 nurses

Some 93.8% (n=255/272) of doctors used their smartphone while at work for communication purposes compared with 28.5% (n=145/509) of nurses (p=0.0001). In the doctor group, 50.2% (n=128/255) were using their smartphone in place of a traditional bleep.

Perceptions regarding the use of smartphones in clinical practice

When presented with a list of adjectives, both doctors and nurses chose positive terms such as helpful, brilliant and essential more frequently than negative terms such as unnecessary, complicated and terrible (figure 2).

Medical app ownership and use

Medical apps were owned by 78.3% (n=202/258) of doctors and 34.8% (n=173/497) of nurses, and this difference was significant (p=0.0001). Of those owning medical apps, a significantly greater number of doctors (n=181/202, 89.6%), compared to nurses (n=116/173, 67.1%), used these apps as part of their clinical practice while at work (p=0.0001). Of those owning medical apps and using these at work, 41.3% (n=74/179) of doctors used the apps weekly and 33.0% (n=59/179) used daily, while in the nurses group 42.0% (n=47/112) used the apps weekly and 22.3% (n=25/112) used daily. Examples of utilised medical apps included drug formularies, medical calculators, disease diagnosis and management, reference and education, procedure documentation, and drug preparation and administration apps.

Recommendation of mHealth apps

Some 9.7% (25/257) of doctors had recommended mHealth apps for use by their patients. Figure 3 highlights reasons for non-recommendation.

Transmission of patient-related clinical information over smartphones

Respondents were asked if they had ever sent patient-related clinical information over their smartphones using short-message-script (SMS), app-based messaging (eg, WhatsApp), and picture messaging (eg, to send a photograph of a wound or X-ray to a colleague for an opinion). In the doctor group, 64.7% (n=176/272) had used SMS, 33.1% (n=90) had used app-based messaging and 46.0% (n=125) had used their smartphone camera and picture messaging (eg, to send a photograph of a wound or X-ray to a colleague for an opinion). The corresponding figures in the nurse group were 13.8% (n=70/509), 5.7% (n=29) and 7.4% (n=38), respectively (figure 4). Doctors were significantly more likely to send patient-related clinical information using these methods (p=0.0001 for all three methods).

Some 27.5% (n=71/258) of doctors and 3.6% (n=70/509) of nurses believed that they still had patient-related clinical information on their smartphones.

Table 1  The demographics of surveyed (a) doctors, and (b) nurses: in terms of age, gender, specialty and level of training or grade.

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FY, foundation year; ITU, intensive treatment unit; O&G, obstetric and gynaecology.
smartphones, and this difference was statistically significant (p=0.0001).

A large proportion of doctors, 71.6% (n=71/258), and 37.2% (n=176/473) of nurses expressed a desire for a secure messaging app to allow transmission of patient-related information to colleagues in a secure way, and this difference was again statistically significant (p=0.0001).

**Own device versus trust-issued device**

In the event that smartphone use became an integral part of the hospital IT infrastructure significantly
more doctors than nurses preferred to use their own device rather than a trust-issued handset (58.5%, n=147/251 vs 21.1%, n=100/473; p=0.0001).

Satisfaction with the survey
When asked if the survey had adequately explored the ways in which they use their smartphones and medical apps at work, 72.4% (n=518/717) of participants ‘strongly agreed’ or ‘agreed’, while 23.3% (n=167) ‘neither agreed nor disagreed’. Just 4.3% (n=32) ‘disagreed’ or ‘strongly disagreed’ with the statement.

DISCUSSION
Previously published surveys have demonstrated that 74.8–83.5% of UK doctors own a smartphone, and 36.8% are in possession of a tablet device.14–16 A slightly higher rate of 85% US doctors have been shown to possess a smartphone, with 56% using medical apps in their clinical practice.13 These surveys were published more than 2 years ago; a relatively long time frame in the rapidly evolving mHealth sector, during which smartphone and tablet technologies have continued to evolve and advance. Ownership and use of these technologies among nursing staff has been poorly explored in the literature to date with only a single published survey, limited by its small sample size (n=82).17

In this work, we have performed an up-to-date pan-specialty, pan-grade survey study of both doctors and nurses at a large NHS Trust, spanning five separate hospital sites, to explore how the ownership and use of smartphones, tablet devices, and medical apps has changed since earlier published surveys, specifically focusing on the clinical environment.

The results demonstrate a large increase in the proportion of doctors owning smartphones (nearly 100%) and tablet devices (approximately 75%). A large percentage of nurses are also carrying these technologies (95% and 65%, respectively). The percentage of front-line staff using medical apps in their clinical practice (90% of doctors and 67% of nurses owning such apps) has also increased, demonstrating a growing demand among doctors and nurses for medical apps that enable them to perform work-related tasks more efficiently.

Interestingly, while the majority of surveyed doctors are using medical apps, very few have recommended them to their patients. A lack of awareness and uncertainties around the evidence base, safety and efficacy are important barriers identified through this survey. If the recommendation of apps is to become commonplace, clinical staff must be able to readily identify higher quality, trust-worthy apps. Currently this is a very challenging process due to the sheer number of mHealth apps available and the absence of robust app certification strategies.

The majority of surveyed staff perceived the clinical use of smartphones and medical apps in a positive light (figure 2), with more than 90% of doctors and half of the nurses identifying their smartphone as either ‘useful’ or ‘very useful’ in helping them to perform their daily clinical duties. Aside from medical app use, staff also found a host of other smartphone features to be of benefit in performing their clinical duties (figure 2). The use of messaging modalities (SMS, picture messaging and/or app-based messaging) is worthy of further discussion.

It is apparent that large proportions of doctors are using messaging services to convey patient-related
Figure 4  (A) A graph showing the percentages of surveyed doctors and nurses sending patient-related clinical information over their smartphones using various messaging modalities. Significantly, more doctors sent patient-related clinical information over all three messaging modalities ($p=0.0001$); (B) A graph showing the frequency with which surveyed doctors and nurses sent patient-related clinical information over their smartphones using various messaging modalities. Compared with nurses, a greater percentage of doctors sent patient-related clinical information on a daily basis using all three modalities, but significance was only reached with short-message-script (SMS; $p=0.014$).
clinical information to colleagues. Nearly two thirds of doctors have used SMS messaging, close to half have used picture messaging (eg, to send photographs of patient wounds or x-rays) and over a third have used app-based messaging to send patient related clinical information. Similar use is demonstrated among nurses, although the proportions are significantly lower. Owing to a lack of data encryption and necessary security modules, the transmission of information through these modalities is currently not secure. Staff clearly find these means of communication to be very useful in their clinical practice, but must take care that any clinical information they are sending does not constitute patient identifiable data, which could potentially lead to the inadvertent disclosure of highly sensitive and confidential information, particularly in the event that handsets are lost, stolen, or viewed by unauthorised users (it should be emphasised that our study did not explore the sending of patient identifiable data specifically).

It is not surprising that 70% of surveyed doctors and 37% of nurses expressed the desire for a secure means of sending patient information to colleagues over their smartphones. While fully secure messaging services for smartphones have recently come into fruition in the USA, similar platforms are not currently available in the UK. Until such time, it is imperative that NHS organisations educate staff on the dangers of sending patient information using unsecure smartphone modalities.

Doctors and nurses must also be aware that the mHealth apps market is currently under-regulated and that defective apps are capable of causing patient harm. Both staff and healthcare organisations should be encouraged to risk assess the medical apps prior to their use in order to mitigate such dangers. A recent paper by Lewis and Wyatt' provides a useful framework for assessing risk in this regard, and standards are available to help NHS organisations manage the clinical risks associated with the deployment and use of Health IT systems. The creation of internal app stores by NHS Trusts may be a useful means of promoting the use of appropriately vetted apps among the employees. Going forward, NHS organisations must ensure that their IT infrastructures (such as Wi-Fi provision) and policies (such as ‘bring your own devices’ policies) are updated to support the safe and secure use of smartphones and medical apps by front-line staff who have adopted these technologies in the work place in large numbers.

Limitations
Several limitations were identified in this study. First, a relatively low response rate was noted. A large proportion of staff failed to open email invitations. This may partly be explained by inaccuracies in staff listings. While the NHS Trust’s governance department could guarantee lists were up-to-date with current staff, they could not give assurances that all the names of the previous staff had been removed. Consequently, response rates may have been higher than those quoted.

Second, the survey was only performed at a single NHS Trust. While this represents a limitation, it should be noted that the investigated Trust consists of five individual hospital sites of varying size, with a mix of teaching and non-teaching units, increasing the generalisability of results.

Third, several survey questions asked if staff had sent ‘patient-related clinical information’ over their smartphones. While this term is not synonymous with ‘patient-identifiable data’, it was purposefully chosen in response to feedback obtained during initial survey piloting. The pilot cohort of doctors and nurses feared answering such questions truthfully, in spite of assurances that responses were fully anonymised, due to a sense of self-incrimination.

Finally, although the survey had not been validated prior to its use, validity was assessed in the survey by asking respondents to what extent they agreed that the survey had adequately explored their uses of smartphones and medical apps at work. Only a very small minority disagreed (4.3%) with this statement, providing evidence of face and content validity.

CONCLUSION
The findings from this study demonstrate that smartphones have become increasingly popular among healthcare professionals who perceive them to be an excellent tool in supporting healthcare delivery. The results provide strong evidence that healthcare organisations need to develop policies to support the safe and secure use of digital technologies in the workplace and that strategies are needed to secure further innovations in digital health.

Correction notice This article has been corrected since it was published Online First. Text changes have been made on pages 1 and 3.

Twitter Follow Maximilian Johnston at @MaxJoJohnston
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Competing interests None declared.
Provenance and peer review Not commissioned; externally peer reviewed.

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