The uses of smartphones and tablet devices in surgery: A systematic review of the literature

Mohammad H. Mobasheri, MRCS, MBBS,[a] Maximilian Johnston, MRCS, MBBS,[b] Usama M. Syed, BSc,[c] Dominic King, MEd, MRCS, MBBS,[b] *and* **Ara Darzi, FRCS, MD,[b]** *London, UK*

Background. *Smartphones and tablet devices have become ubiquitous, and their adoption in the health care arena is growing. Reviews have looked at their utilities within medical specialties. Despite the many surgical apps available currently, there has not been a comprehensive literature review evaluating uses of these platforms within surgical disciplines. We reviewed the literature systematically in this regard.*
Methods. *Embase, MEDLINE, Health Management Informatics Consortium, and PsychINFO databases were searched for empiric quantitative studies evaluating interventions based in the use of smartphone or tablet device within surgical disciplines targeted at surgeons, patients, or the wider public.*
Results. *Of the 39 studies included, 24 evaluated smartphone-based interventions and 15 looked at tablet devices, whereas 30 were app-based interventions and 9 were not. A wide range of effective and innovative utilities were identified and categorized into 8 domains; Diagnostics (n = 11), telemedicine (n = 9), operative navigation (n = 6), training (n = 5), data collection (n = 3), patient education (n = 2), behavior change (n = 2), and operative planning (n = 1).*
Conclusion. *This comprehensive systematic literature review of smartphone and tablet device use in surgery demonstrates a wide range of innovative utilities in the pre-, intra-, and postoperative contexts. Although results of individual studies generally were favorable, limitations in methodologies existed in many, and although studies clearly highlight the substantial potential of smartphone and tablet devices in the surgical setting, trials of greater quality will be necessary to pave the way for their widespread adoption. (Surgery 2015;158:1352-71.)*

From the Department of Surgery & Cancer,[a] Institute of Global Health Innovation,[b] and Faculty of Medicine,[c] Imperial College London, London, UK

The past 2 decades have seen a surge in consumer demand for portable hand-held communication devices. Since 2007, the handsets of the older mobile phones and personal digital assistants have been replaced gradually by more sophisticated devices, such as smartphones and tablet computers, capable of running stand-alone software applications or "apps." These technologies have spread and evolved at an unprecedented rate.[1] It is estimated that 65% of the United States population now owns a smartphone and 48% owns a tablet device.[2]

Substantial interest has arisen around the use of smartphone and tablet technologies in the health care context. This interest has brought the field of mobile health (mHealth), defined as the delivery of health care and health-related services via communications devices, into sharp focus.[3] Such devices are carried in the pockets of the majority of health care professionals working in developed health care systems,[4-6] and there are currently more than 40,000 mHealth apps available for download through app stores.[7] The mHealth sector as a whole is expected to generate approximately $26 billion by the end of 2017.[8]

Although limited currently, the evidence base for health care interventions delivered over these platforms is growing steadily. Recent literature reviews have evaluated the uses of smartphones and tablet devices both within the context of

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Reprint requests: Mohammad H. Mobasheri, MRCS, MBBS, Division of Surgery, Department of Surgery & Cancer, Imperial College London, 10th Floor QEQM building, St Mary's Hospital, Praed Street, London W2 1NY, United Kingdom. E-mail: m.mobasheri@imperial.ac.uk.

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specific disease processes such as diabetes[9] and the general medical field as a whole.[10]

Over the decades, surgeons often have challenged the status quo and adopted new technologies in their endeavors to enhance operative technique and improve patient outcomes,[11] as demonstrated by the adoption of laparoscopy. Despite a tradition rich in innovation and more than 600 surgery-related apps available already for download,[12] to date there has not been a comprehensive literature review that evaluates the uses of smartphone and tablet platforms within the house of surgery.

We adopted a systematic approach to identify, appraise, and discuss the available literature addressing the uses of smartphones and tablet devices, both app- and nonapp-based, within surgical disciplines and included interventions targeted at surgical health care professionals, patients, and the public.

METHODS

This review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for systematic reviews.[13]

Database search. The Embase, MEDLINE, Health Management Informatics Consortium, and PsychINFO databases were searched through OVID on May 5, 2014 with the search string Smartphone.mp OR Smart phone.mp OR Nokia.mp OR Symbian.mp OR iPhone.mp OR iPod.mp OR iTunes.mp OR Apple.mp OR Android.mp OR iOS.mp OR Blackberry.mp OR Windows.mp OR mHealth.mp OR Mobile Health.mp OR App.mp OR Google Play.mp OR App Store.mp OR Tablet.mp OR iPad.mp, combined with the term Surg*.mp using the 'AND' Boolean operator. The search was limited to articles published in the English Language from the year 2007 onwards, because this year was the release year of the first modern-day smartphone and tablet device.

Inclusion and exclusion criteria. For the purposes of this review a smartphone was defined as a mobile phone offering additional functionality through built-in sensors and capable of running stand-alone software applications or apps. A tablet device was defined as a single panel, handheld, general-purpose computer. Only devices running the iOS, Android, BlackBerry, Symbian, or Windows operating systems were included. Use of such operating systems are a defining feature of newer devices. Older mobile phones and personal digital assistants were excluded from the review due to their comparatively limited functionality.

Empiric quantitative studies evaluating the use of smartphone or tablet-based interventions within surgical disciplines were included, regardless of the target population (eg, the public, patients, surgeons) or outcome measures, in keeping with the broad nature of this review. Dermatology and dentistry were not considered to be surgical specialties and were excluded.[14] Voice call- and short-message-script–based interventions were also excluded because these have been reviewed extensively in earlier works[15-18] and are not unique to smartphones. Other article types, that included case studies, conference proceedings, editorials, and reviews, were also excluded.

Screening process. Screening of article titles and abstracts was performed by 3 reviewers (M.M., M.J., U.S.). Full texts of potentially relevant studies were retrieved and reviewed against the specified inclusion criteria (M.M., M.J.). Any disagreements were resolved through discussion with a third investigator (D.K.) for consensus. Reference lists of included studies were scanned to identify other potentially relevant articles.

Quality assessment. Quality assessment of included articles was undertaken using the quality checklist for quantitative studies of the Alberta Heritage Foundation for Medical Research.[19] This specific tool was chosen, because it provided a quantitative means of evaluating the wide range of study designs included in the review. Because of the limited amount of literature relevant to our review question, studies were not excluded based on their quality assessment scores.

RESULTS

Database search results. The database search identified 2,706 articles (Fig 1). Initial screening of titles and abstracts excluded 2,554. Further abstract screening of the remaining 153 articles against a more strictly defined set of inclusion criteria excluded another 85. In this regard, reviewers screened independently 10% of articles, and the consistency of selection was high ($\kappa = 0.818$, $P = .001$). After the removal of duplicates, 44 articles were retained for full text review. Thirty-three of these met the inclusion criteria, and a further 6 studies were identified and included through screening of the reference list, bringing the total number of included studies to 39. Each of these studies evaluated a single smartphone or tablet-based intervention.

Study characteristics. Among included studies, a variety of intervention types were identified and