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Digital health interventions for osteoporosis and post-fragility fracture care

Amit Gupta*, **Christina Maslen***, **Madhavi Vindlacheruvu**, **Richard L. Abel**, **Pinaki Bhattacharya**, **Paul A. Bromiley**, **Emma M. Clark**, **Juliet E. Compston**, **Nicola Crabtree**, **Jennifer S. Gregory**, **Eleni P. Kariki**, **Nicholas C. Harvey**, **Eugene McCloskey**, **Kate A. Ward** and **Kenneth E.S. Poole**; **On behalf of the Technology Working Group of the Royal Osteoporosis Society Osteoporosis and Bone ResearchAcademy**

***Abstract*:** The growing burden from osteoporosis and fragility fractures highlights a need to improve osteoporosis management across healthcare systems. Sub-optimal management of osteoporosis is an area suitable for digital health interventions. While fracture liaison services (FLSs) are proven to greatly improve care for people with osteoporosis, such services might benefit from technologies that enhance automation. The term 'Digital Health' covers a variety of different tools including clinical decision support systems, electronic medical record tools, patient decision aids, patient apps, education tools, and novel artificial intelligence (AI) algorithms. Within the scope of this review are AI solutions that use algorithms within health system registries to target interventions. Clinician-targeted, patient-targeted, or system-targeted digital health interventions could be used to improve management and prevent fragility fractures. This review was commissioned by The Royal Osteoporosis Society and Bone Research Academy during the production of the 2020 Research Roadmap (https://theros.org.uk), with the intention of identifying gaps where targeted research funding could lead to improved patient health. We explore potential uses of digital technology in the general management of osteoporosis. Evidence suggests that digital technologies can support multidisciplinary teams to provide the best possible patient care based on current evidence and to support patients in self-management. However, robust randomised controlled studies are still needed to assess the effectiveness and cost-effectiveness of these technologies.

Keywords: digital health, osteoporosis, fracture, bone density

Correspondence to:
Kenneth E.S. Poole
University of Cambridge School of Clinical Medicine, CB2 0QQ Cambridge, UK.
kenneth.poole@nhs.net

Amit Gupta
Moorfields Eye Hospital NHS Foundation Trust, London, UK

Christina Maslen
Health Evidence Matters, Bristol, UK

Madhavi Vindlacheruvu
Addenbrooke's Hospital, Cambridge, UK

Richard L. Abel
Imperial College London, London, UK

Pinaki Bhattacharya
Eugene McCloskey
The University of Sheffield, Sheffield, UK

Paul A. Bromiley
Eleni P. Kariki
The University of Manchester, Manchester, UK

Emma M. Clark
University of Bristol, Bristol, UK

Juliet E. Compston
Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK

Nicola Crabtree
Birmingham Women's and Children's NHS Foundation Trust, Birmingham, UK

Jennifer S. Gregory
University of Aberdeen, Aberdeen, UK

Nicholas C. Harvey
Kate A. Ward
University of Southampton, Southampton, UK

*These authors contributed equally

Introduction and background

Digital health interventions aim to electronically connect points of care to provide easier and more secure sharing of relevant health and well-being data. Within the field of bone health, such technologies encompass the following:

- Electronic patient records.
- Clinical decision support systems (CDSSs).
- Decision aids for patients.
- Digital health-supported patient communication.
- Electronic mobile applications.
- e-Triage.
- e-Consult systems.
- Digitally delivered osteoporosis education for clinicians.
- Information for patients.
- Artificial intelligence (AI) approaches to case finding.

In many countries, the embedding of digital technologies into healthcare is now seen as a priority, and their use is encouraged by a range of government policy initiatives.[1]

Osteoporosis is a disease characterised by reduced bone mass resulting in an increased risk of low-trauma fractures. These fragility fractures are associated with high morbidity and mortality as well as significant financial burden to health services worldwide.[2] Globally, 1 in 3 women over the age of 50 will experience fragility fractures, as will 1 in 5 men. In the United Kingdom, it has been estimated that 3 million people have osteoporosis, with over 500,000 fragility fractures annually, costing the NHS £4.4 billion per year.[3] Meta-analyses confirm that individuals with prior fracture have a greatly increased risk of future fracture, independent of the risk attributable to low bone mineral density (BMD) or fracture site.[4] 'Secondary prevention' measures among people who have sustained a first fragility fracture are seen as the key to avoiding significant and growing, economic and health burden of osteoporosis, and intervening in those people who have had a fracture is an area ripe for the application of digital health solutions. Although the precise nature of different fracture liaison services (FLSs) varies, a significant body of international evidence garnered over decades has demonstrated that FLS programmes are effective; increasing detection and overall management of osteoporosis; improving patient adherence to long-term treatment; and improving post-fracture treatment, reducing recurrent fracture rates and saving hospital costs.[5–11] This includes level-1 evidence from systematic reviews with meta-analyses that FLS increase evaluation and treatment for osteoporosis including holistic care for the frail elderly after hip fracture.[9,12]

This is a 'rapid evidence review' and aims to provide a comprehensive review of the topic, it is not a full systematic review of all related literature. The recently published Cochrane guidance on the methodology of rapid review defines it as 'A form of knowledge synthesis that accelerates the process of conducting a traditional systematic review through streamlining or omitting specific methods to produce evidence for stakeholders in a resource-efficient manner'.[13] Rapid evidence reviews are developed primarily by request for prompt evidence to help address urgent and emergent health issues deemed high priority.[13] With digital technology constantly evolving and the ever-growing burden of fragility fractures and osteoporosis to patients, this review was formulated as a repository of existing technologies as well as touching on future technologies.

It does not cover AI methods for image analysis, covered in our separate review for the journal.

Methodology

Data sources

Data sources searched included:

- NICE Evidence library portal.
- Systematic reviews via: Cochrane Library.
- Electronic bibliographic databases: Embase, Medline; Tripdatabase; and Web of Science.
- Websites: NICE; NHS England and Improvement; King's Fund and Nuffield Trust.
- Search engines: Google Scholar and Google.
- Theses and dissertations via: EThOS, PQDT Open, EBSCO Open Dissertations, NDLTD: Networked Digital Library of Theses and Dissertations, OATD: Open Access Theses and Dissertations, DART-Europe, Theses Canada, Trove.

Search strategy

A Boolean search strategy was applied using the operators AND, OR, and NOT in combination with the following keywords; index headings and free text. Truncation techniques using asterisks and wildcard techniques using question marks were employed when free text searching:

'digital technolog*', 'digital solution*', eHealth, 'digital health technolog*', 'digital health solution*', 'machine learning', 'cloud-based', 'cloud computing', 'Digital transformation', 'digital translation', 'information technolog*', 'connected health', app, 'mobile application', 'mobile health application', 'mobile phone', 'decision support', 'decision aid', 'electronic patient record*', 'electronic health record*', reminder*, alert*, 'Fracture Liaison Service*', 'fragility fracture*', osteoporosis, 'care pathway', 'treatment pathway', 'clinical pathway'.

In addition, reference lists of key relevant primary research, systematic reviews and meta-analyses and grey literature were examined to identify further studies. Citation searches of key relevant articles were undertaken. Targeted searches for publications by key academic researchers were made.

Searches were limited to English language.

Findings

Digital Health – definitions

The World Health Organization (WHO) definitions of digital health and digital health interventions states:

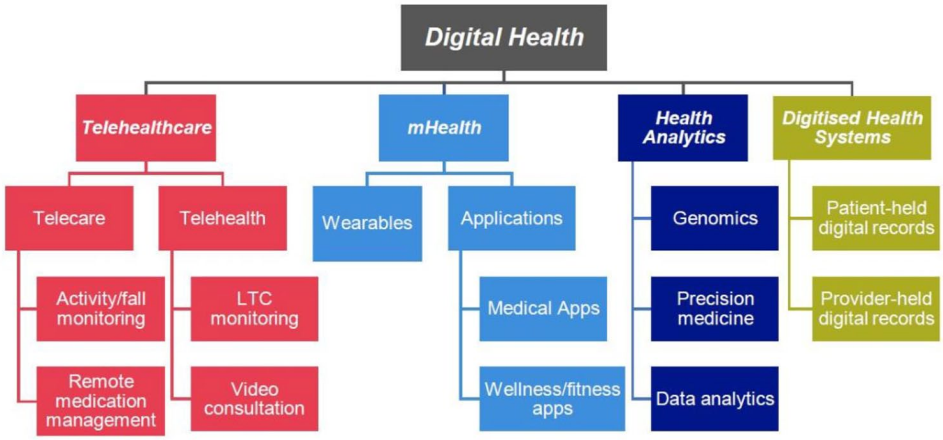

Figure 1. Sub-categories of digital health.
Source: Adapted from Deloitte UK (2015).[15]

> The use of digital, mobile and wireless technologies to support the achievement of health objectives. Digital health describes the general use of information and communications technologies (ICT) for health and is inclusive of both mHealth (Mobile Health) and eHealth (Electronic Health) ... the application of digital, mobile and wireless technologies for a defined health purpose, in order to address specific health system challenges. (Figure 1)[14]

Digital Health in fracture risk assessment and osteoporosis identification

Fracture risk-assessment tools such as the FRAX online calculator are the most obvious osteoporosis-specific application of digital health. Calculating an individuals' 10-year risk of fracture is chiefly used to identify individuals who would benefit from osteoporosis treatment. Adoption, applicability, and therefore effectiveness of FRAX in osteoporosis case finding is intrinsically limited by human factors; specifically, the clinicians inclination to routinely manually enter clinical data and translate outputs into clinical practice. The National Osteoporosis Guidelines group (NOGG) has extended the utility of the FRAX Digital Health approach by electronically linking 10-year fracture risk values to agreed treatment thresholds, giving the clinician a simple visualisation of whether to offer treatment or reassure.[16] One online alternative to FRAX, QFracture is fully integrated into the primary care digital system and automatically calculates fracture risk without the need for manual data input but is hampered by lack of bone density input and link to National Guidelines.[17] It does, however, try to permit patients to perceive their risk graphically using basic 'smiley' face grids of 100, with adverse outcomes shown by coloured 'unhappy' faces. As we will highlight later, this area of helping patients perceive risk is central to osteoporosis and fragility fracture care, and ripe for the application of more sophisticated, useful digital health measures.

Digital Health and improving FLS models. There are now at least 225 FLS in over 35 countries (International Osteoporosis Foundation data)[9] since the first successful demonstration of the clinical utility of this model of care in 1999.[18] Despite differences between primary and secondary care models, a common factor within these programmes is they are usually coordinated by specified individual(s), usually clinical nurse specialists, who case-find, work to prescribed protocols with assistance and refer access to specialist clinicians.[19] Digital Health tools comprising reminders, risk assessment, or education can reduce secondary fracture rates and increase BMD investigations and the initiation of osteoporosis therapy.[20–25] Tools that target both clinicians and patients, and those that consist of multiple components (such as reminders and education) are associated with greater improvement in outcomes.[24,26,27] Many of the evaluative randomised controlled trials (RCTs)[28–30] are of poor methodological quality, lacking the reporting of appropriately used methods of randomisation and its concealment, blinding, and follow-up in the studies.

The Fracture Liaison Service Database (FLS-DB) is an exemplar of digital health to support post-fracture care and reduce fracture risk and is unique as a national patient-level audit. FLS-DB aims to measure the volume and quality of care in secondary fracture prevention delivery across England and Wales, having begun with a hip fracture–specific database (which linked improved hip fracture management to financial incentives). High quality of care is achieved by facility and patient audits that aid identification of shortcomings in the service that can be altered or improved. It was commissioned by the Healthcare Quality Improvement Partnership (HQIP) as a new national audit as part of the Fragility Fracture Audit Programme (FFFAP) delivered by the Royal College of Physicians (RCP).[31–33] From the 2020 RCP annual database report, 69 FLSs submitted patient data from over 180,000 patients in England and Wales. Local commissioners and FLSs can use the report results to improve post-fracture care delivery through service improvement and/or additional commissioning to reduce the number of preventable fragility fractures.[31] Limitations of FLS-DB are the necessity to manually upload patient-level data, a shortcoming when very many variables are already captured in individual hospital-level electronic medical records (EMRs). Linkage of EMR and FLS-DB would greatly facilitate utility.

MedCert FLS App introduced a digital '5i' step approach (identify, inform, initiate, investigate, and iterate) to the management of patients with fragility fracture in participating providers within the United States and is an example of a secure, HIPAA (Health Insurance Portability and Accountability Act of 1996) compliant, cloud platform using software.[34] The software can support large numbers of concurrent users and can be easily accessed remotely through a device with Internet access. It proved to be an effective method to monitor and treat patients following a fragility fracture. The app allows the FLS coordinator to monitor all patients at a glance; ensuring assessments and clinical reviews have not been missed.

The UK 2020 FLS-DB audit report[35] recommended improved engagement with primary care to enhance monitoring of treatment adherence, vertebral fracture identification, and called for more timely access to DXA scans. Since FLS coordinator led care reduced re-fracture rates, improved surrogate measures (BMD testing rates; treatment initiation rates), and overall health costs, the system is an obvious target for the application of digital health.[19,36] Eventually, the 'Internet of things' (IoT) might prove useful in linking patients and their digital devices directly with FLS functions. This is particularly relevant to care of the elderly, whereby virtual and physical technologies such as sensors, actuators, and devices interacting wirelessly, could lead to health benefits such as falls prevention and medication adherence in older people.[37] Initial forays include an app which takes on some components of an FLS (patient-level reminders about fall prevention strategies, FRAX calculation, exercise and nutrition recommendations, recommendations to modify particular risk factors including sunshine exposure) but are at the experimental stage.[38] In the future, integration of, for example, chair-based sensors, cameras, or real-time visualisation of balance are potential avenues to explore[38] for falls prevention and fracture care in the elderly.

Digital Health and osteoporosis identification, via clinician support systems, prompts, and reminders. A CDSS is an aid for clinicians in their day-to-day decision-making. They are primarily used at the point-of-care, where clinicians can combine their knowledge with information provided by web-applications, electronic health records (EHRs) and computerised provider order entry (CPOE) systems. A CDSS is typically accessed through desktop, tablet, smartphone, and other devices.[39] A good example of a CDSS is the Icelandic Osteoporosis Advisor (OPAD), which helps identify individuals at increased risk of fracture, based on comprehensive guidelines and risk factors. OPAD prompts the clinician with primary prevention advice, evidence-based treatment recommendations, and advice on follow-up.[22,23] Prompts or alerts are part of common practice in primary care enabled through the use of EHR. There are integrated reminders within a CDSS. Evidence suggests that their use increases compliance with guideline practice.[25] CDSSs may also prove suitable for the application of logic-based AI approaches.[40] Key limitations to CDSS adoption include the difficulty of integration with legacy and established EHRs and cost-effectiveness.[40]

A Cochrane review comprising five RCTs and a meta-analysis reaffirmed the use of alerts in improving guideline practice.[29] Despite this, there is a lack of robust evidence on what types of alerts, reminders and prompts should be used and how they should be deployed to most positively impact practitioner practice and improve patient outcomes.[25] There are, however, examples of enhanced improvements in osteoporosis management using computerised system alerts.[21] A Canadian osteoporosis assessment tool, used in primary-care settings, helps to screen and manage patients at point of care by nesting Canadian osteoporosis guidelines within the EHR system. By identifying and alerting clinicians to patients at risk of developing osteoporosis, improvements to the management of fragility fractures, supported proactive care, and continued monitoring based on Canadian best practice recommendations are achievable.[41]

Digital Health and e-Consultation/e-Triage at the interface between primary- and secondary-care services. In many countries, the demand for osteoporosis services exceeds the supply, resulting in limited access. The traditional approach of direct face-to-face clinical encounters is challenging, particularly with the coronavirus pandemic. Efficient referral management in high-demand specialties is critical to ensure that the highest quality of care is provided. An electronic triage system *via* email for new outpatient referrals resulted in increased clinical efficiency and higher satisfaction for patients and health workers.[42]

The Northern Ireland Electronic Health Care Record (NIECR) system has been adapted to include electronic triage and e-triage into the osteoporosis service. Its purpose is to streamline the screening process and address the extensive waiting times for access to medical services. The new service includes the option of 'advice only', direct to investigation with DXA or face-to-face appointments at the consultant-led complex osteoporosis service. There is a high degree of agreement for the triage category between the referring clinician and specialist services: 73.3% of patients attended a face-to-face appointment at the consultant-led clinic and active triage enabled investigation in 18.4% and discharge in 8.3%. This demonstrates that e-triage supports effective referral management in a busy osteoporosis service, with potential further improvement using greater multidisciplinary team access.[43] One limitation to the scaling up of such digital health innovations as NIECR, is the large variety and lack of national consensus in the optimal pathway; systems can be only adopted elsewhere if they can map to the NIECR model.

A large study performed in the United States (2775 fracture episodes), with a centralised electronic triage system, enabled assessment of the cohort of individuals who lived in rural or highly rural areas (53.3% of total fracture episodes). The nurse liaison service significantly improved the rates of bisphosphonate prescription and BMD testing, for both urban and rural patients.[44] This study highlighted that despite the high demand on services, high-quality care was provided, regardless of location, by optimising referral and screening systems.

More recently, NHSX partnered with Open Medical Ltd. to produce e-Trauma software,[45] a cloud-based patient management system. The use of cloud-based, learning natural language processing algorithms, and structured granular data sets helped to improve data quality, and by processing this detailed data, a new digital FLS model of care emerged. This automatically detects patients who may benefit from secondary osteoporosis prevention at the time of initial orthopaedic trauma referral. It is possible that this 'data-driven' care might improve identification of patients, enhance coordination, and collaboration of teams (e.g. between fracture clinics and FLS) as well as increase the overall quality of patient care, but both clinical effectiveness and cost-effectiveness data are needed.[46]

Use of Digital Health in patient decision-making, communication, and education

Decision aids for patients and shared decision-making. Shared decision-making has never been more important than now in the field of osteoporosis treatment. The process by which a health care choice is made by the patient, family, or carers, with one or more healthcare professionals is evolving, particularly in light of patient access to the 'wild west' of clinical and quasi-clinical information online.[47] While the medication leaflet must contain comprehensive information and carefully curated evidence-based and balanced resources such as Royal Osteoporosis Society medication leaflets are universally distributed at the point of care, patients are increasingly likely to 'do their own research online', particularly in regard to rare and very rare osteoporosis drug side effects. This is where decision aids can be helpful as evidence-based tools to support shared decision-making in practice.[24] Particularly relevant to osteoporosis care is that these tools have been shown to improve the accuracy of patient risk perceptions. In osteoporosis, this risk perception is key to whether a person feels willing to take a therapy to prevent a painful event that is in part due to chance (fragility fracture). Tools that are web-based can be rapidly updated and disseminated. When used appropriately, such aids can improve patient–clinician rapport and as a result the development of an appropriate and open treatment plan, often with regard to commencement of drug treatment. An example of a decision aid is 'The Osteoporosis Choice Decision Aid' developed in 2008. It was designed for use by patients and their clinicians to facilitate shared decision-making. It incorporates a patient's 10-year risk probability of fracture estimated using the FRAX online calculator. It was compared in an RCT to usual care with and without the FRAX fracture risk, and its use reduced decisional conflict, increased treatment initiation, and improved patient knowledge and engagement.[48]

An important limitation to adoption is that some decision aids have been shown to make little or no difference to the number of healthcare professionals adhering to guideline practice and some aids have failed to meet international quality standards.[19,49] Decision aids for patients are not always popular with patients; many patients still expect their physician or specialist to fulfil all the decision-making roles that such digital health technologies can enable.[50] Although patient decision aids seem promising for improving osteoporosis management, fundamental problems with available patient decision aids have been identified,[50] and it is critical that such aids use the best available evidence and/or have presented it appropriately.

Digital health–supported patient communication. Most patients with osteoporosis want information about the condition, risk of fracture, treatment, and understanding the role of BMD testing to enable self-management.[51] Interactive voice response (IVR) systems as well as more sophisticated forms of multimedia technologies to motivate and educate patients may have a role. Digital health interventions can range from simple voice call to more sophisticated application of multimedia technologies. A recent review concluded

> that a person-centred and integrated model of care can be delivered to older people with fragility fractures with the support of digital health technological solutions and achieve desired outcomes. Resources to optimise pain management, physical activity, nutrition, sleep hygiene and mental health could all be integrated. The provision of health information in isolation does not equate to education. Monitoring and feedback of progress are critical. Techniques such as behaviour change and motivational interviewing need to be integral to the service.[30]

After the immediate discharge period, patients are often left alone to navigate the healthcare system leading to poorer post-fracture outcomes. Digital health studies should be undertaken with the intention of addressing broader populations with other complex diagnoses requiring more person-centred and integrated care.[30] An IVR system developed in the United States, screened high-risk postmenopausal osteoporotic women using a script lasting 4–5 minutes long. Compared to an RCT where educational packages were mailed to patients on top of their usual care, no clear benefit was seen.[52] The diverse types of the tools available increase the difficulty in determining which tool is most effective.

Digital health–supported professional clinical education. A US model called Project ECHO (Extension for Community Healthcare Outcomes) is a technology-enabled collaborative learning system for healthcare workers in the management of skeletal diseases. Bone Health TeleECHO uses weekly videoconferencing to link healthcare professionals of varied experience and expertise to interact on the subject of osteoporosis.[53] Self-efficacy outcomes showed that regular Bone Health TeleECHO participants experienced a statistically significant improvement of confidence in managing each of 20 different domains of osteoporosis care.[54] The ability to share knowledge and advice through videoconferencing technology allows for discussion of individualised treatment decisions outside of trust guidelines or personal preferences.[54]

Digital health–supported patient education. A multimodal, patient-centred, tailored, video-based behavioural intervention to encourage patients to seek osteoporosis diagnosis and treatment has been developed and evaluated in the Activating Patients at Risk for Osteoporosis (APROPOS) study. Intervention materials comprising personalised videos were emailed to a personalised webpage and also mailed in a DVD format. The intervention also included follow-up telephone calls and IVR reminders to view the videos. At 6- and 18-month intervals, there was no significant difference in rates of self-reported treatment initiation and follow-up.[55] Multimedia as a patient education tool comprising learning modules with information on osteoporosis, risk

Table 1. Example of osteoporosis mHealth app.

App	Features
FRAX App	The Fracture Risk Assessment Tool App (FRAX® App), developed by the Centre for Metabolic Bone Diseases at the University of Sheffield, UK, is an easy-to-use app to calculate an individual patient's 10-year probability of a major osteoporotic event (clinical spine, forearm, hip, or shoulder fracture) and probability of an osteoporotic hip fracture from inputting simple clinical and demographic details. For use by clinicians, the App is PIN Protection for saved assessments, features patient results management (save, delete, and sort options) and E-mail sharing capability of patient assessment (responses and results).
My Osteoporosis Journey–Denmark	For women with newly diagnosed asymptomatic osteoporosis. Aims to support patients in treatment decision-making, self-management, and used as an addition for healthcare workers in primary and secondary care.[59] Qualitative evidence suggested that the app reduced anxiety, gave patients more confidence and a feeling of reassurance. Achieved by allowing more control – test results to be seen before primary-care physicians and support in self-management.[60]

FRAX, Fracture Risk Assessment Tool.

factors, prevention, and management using a set of dramatised video clips is comparable to a printed booklet containing similar information.[56]

Smartphone-based electronic mobile applications

Mobile health (mHealth) is an ever-expanding area of health delivery and has the potential to complement other healthcare technologies. Mobile applications (apps) are used frequently in daily life, with over 100,000 accessible apps being health care related.[57] Evidence suggests that mHealth apps improve symptom control through self-management and that these apps have the potential to improve health outcomes in those with chronic diseases.[57] However, there are relatively few specifically for osteoporosis and scarce quality control or regulation of app developers. The use of mHealth technology in relation to osteoporosis is expanding, but the value of these apps in this condition is under-evaluated.[58] Tables 1 and 2 show examples of mHealth apps either being tested or commercially available. Apps appear popular among users, and there is some evidence to indicate that an older population would be willing to use them.

AI, machine learning, and their application to EHRs for falls and fracture risk prediction

Computer-based algorithms or prediction algorithms have been developed to identify fracture risk using different input datasets. They assist clinicians through calculation of 5- or 10-years risk of fracture based on known risk factors. There is no gold standard fracture assessment tool, although a recent systematic review suggests that QFracture, Fracture Risk Assessment Tool (FRAX) alongside BMD, and Garvan alongside BMD are the tools with the best discriminative ability.[59] A more efficient way to assess fracture risk would be from routinely available, easily accessible, population-based, administrative healthcare data. Data entry could be automated and integrated into EHRs, allowing risk assessment to be provided at the point of care hence guiding clinician management. Ideally, this would be centralised and act as a screening tool for a wider population. Formulating fracture risk scores derived from information available in routine population-based healthcare data is of considerable interest. Using the power of large data sets and AI with machine learning to identify individuals at high risk of fracture from routinely acquired data is feasible. A Danish study describes the development and validation of a prediction model (FREM) for men and women at high risk of major osteoporotic fractures or hip fractures. It utilised administrative ICD-10 data alone from public health registries with information on the total population aged 45 and older.[62] FREM lends itself to automation as it is driven entirely by routinely collected administrative data with no manual data entry at the point-of-service delivery. FREM found several recognised risk conditions for osteoporotic fractures, with age being the most important followed by a history of previous osteoporotic fractures at different locations and frailty or high risk of falls. The FREM tool and

Table 2. Free apps through search on app store (Apple, California, USA).

App	Features
Hip Fracture Risk Calculator	A calculator for risk of hip fracture and risk of in-hospital mortality after hip fracture, based on patient demographics and comorbidities. Hip fracture risk calculation is based on Nguyen *et al.*[61]
AACE Osteoporosis Treatment Algorithm	An algorithm which guides the user through the diagnosis and treatment options for postmenopausal osteoporosis based on guidelines developed by the American Association of Clinical Endocrinologists (AACE)
My Osteoporosis Manager @Point of Care	A management tool that enables patients with osteoporosis to track and store relevant health information between clinician visits. It includes the ability to capture detailed information regarding health in a digital journal; management of medications and treatments; tracking of osteo-specific symptoms and side effects; easy-to-understand charts that record test results and medication adherence; access to patient education materials; ability to share information with the patient's healthcare provider
BoneGauge HarborLight Solutions LLC	This app allows the user to approximate an individual's bone density and quality from a mobile platform. It helps make measurements of cortical thickness of the second metacarpal from either hand or wrist X-rays from a photograph of an X-ray

AACE, American Association of Clinical Endocrinologists.

others like it are currently being evaluated for direct integration into EHR systems and nationwide patient information registries. Integration will automate the process, reducing reliance on human effort.[62,63]

In the United States, using EHR data and advanced machine learning algorithms, an EHR-based fall risk predictive model has been developed and validated to estimate a patient's risk of falling within the following 12 months.[64] The algorithm, XGBoost, automatically integrates relevant information concerning disease diagnoses, medication use, clinical factors, and laboratory test results to compute its prediction and identify 'high fall risk' individuals. The model successfully captured 58.01% and 54.93% of falls that happened within 30 and 30–60 days of calculation. A total of 50% of the identified high-risk true positives were confirmed to fall during the first 94 days of the next year, indicating the model's better performance for short-term fall prediction.[64]

Use of digital technologies: a few words of caution

Workforce implications. A recent national review[65] makes recommendations concerning the creation of a digitally competent workforce, with three principles to support implementation of digital technology:

- Patients should be suitably informed about health technologies, with particular focus on vulnerable groups to ensure fair access.
- The healthcare workforce needs knowledge and guidance to evaluate new technologies.
- The adoption of technology should be used to give healthcare staff more time to care and interact directly with patients.[65]

Governance and ethics. Using AI in clinical practice comes with an additional set of challenges and has huge implications for accountability, regulation, governance, and ethics. It has been suggested that the four primary ethical challenges are informed consent to use, safety and transparency, algorithmic fairness and biases, and data privacy.[66] '*Regulating algorithms in healthcare*', a project led by the PHG Foundation, University of Cambridge, focused on how algorithms in healthcare are currently regulated. They made recommendations for improvement to ensure a suitable balance between the need for medical innovation and patient safety.[67,68]

Conclusion

Development and implementation of digital technology is increasing rapidly. Healthcare departments are keen to partner with academics, industry, and the commercial sector in order to deliver trustworthy digital solutions to improve patient care. Evidence suggests that digital technologies can support multidisciplinary teams to provide the best possible patient care based on current evidence and to support patients in self-management. Two factors need to be considered; (1) the methodological quality of many of the studies that evaluate these technologies is low, limiting validity and (2) most studies have been undertaken in a variety of global settings. Therefore, robust randomised controlled studies are still needed to assess the effectiveness and cost-effectiveness of these technologies, particularly in mHealth. Finally, in order for technology to be embraced and embedded in practice, it is important to have a digitally competent workforce who can effectively use these technologies.

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Author contributions

Amit Gupta: contribution is Project Administration, Writing – original draft; Writing-reivew & Editing.

Christina Maslen: Conceptualisation; Formal analysis; Investigation; Methodology; Project administration; Validation; Writing – original draft; Writing – review & editing.

Madhavi Vindlacheruvu: Writing – review & editing.

Richard L. Abel: Writing – review & editing.

Pinaki Bhattacharya: Writing – review & editing.

Paul A Bromiley: Writing – review & editing.

Emma M. Clark: Writing – review & editing.

Juliet. E. Compston: Writing – review & editing.

Nicola Crabtree: Writing – review & editing.

Jennifer S Gregory: Writing – review & editing.

Eleni P. Kariki: Writing – review & editing.

Nicholas C Harvey: Writing – review & editing.

Eugene McCloskey: Writing – review & editing.

Kate A Ward: Writing – review & editing.

Kenneth E.S. Poole: Conceptualisation; Formal analysis; Funding acquisition; Software; Supervision; Validation; Visualisation; Writing – review & editing.

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ORCID iDs

Amit Gupta https://orcid.org/0000-0002-1046-3784

Jennifer S. Gregory https://orcid.org/0000-0002-6328-4560

Kenneth E.S. Poole https://orcid.org/0000-0003-4546-7352

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