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Vitamin D Mobile Healthcare Applications for Consumer Use - Are They Any Good?

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Abstract Introduction: Members of the public interested in changing their health behaviour and comfortable with use of social media can download and purchase commercially developed lifestyle and or healthcare computer software. This is facilitated by the increase in technologically advanced, often elegantly designed, small screen portable in-built computerised systems on mobile smart-phones. Aims: With increasing awareness of use of Vitamin D for improved health outcomes, the aims for this study were to identify and evaluate any Vitamin D mobile smart-phone healthcare applications (apps) available for public or consumer use. Methods: Incorporating a multi-phase mixed study design, in phase one Vitamin D apps on mobile smart-phones were identified and categorised by consensus using the Delphi technique. In phase two a database search was undertaken to gain an understanding of research undertaken on use of healthcare apps and any evaluation of outcomes. In phase three a modified validated mobile applications rating scale (MARS) was utilised to evaluate the apps identified in phase one. Each app that provided some health information was assigned objective scores for information quality, and subjective quality and app specific rating scores. Discussion: No Vitamin D apps were identified where evaluation in research trial settings has shown significant beneficial health outcomes. However the literature search helped to identify criteria that form a potential checklist for any future development of a Vitamin D app for consumer use. Use of the modified MARS, with scores assigned for validated information quality criteria, identified two apps which were rated highly but with use restricted to medical teams, and seven apps focusing on dietary intake. Results: Nine apps were identified supporting some level of healthcare delivery and assigned MARS scores. Seven of these apps focused primarily on Vitamin D nutritional support. There were no high quality Vitamin D apps identified that could help consumers with decision on Vitamin D supplementation.

Keywords: *Vitamin D, healthcare, consumers, social media, mobile phones, applications*

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1. Background

Mobile healthcare applications (Apps) were downloaded an estimated 660 million times by June 2013 and industry experts project that around 1.7 billion mobile users will use healthcare apps on a fairly regular basis by 2018 [1]. Concerns however around the impact and quality of care provided to patients who use health apps in clinical practice have been raised [2,3]. Caution has been advised when using apps as they may not incorporate robust scientific evidence [2,3,4,5], may not have had expert clinically oriented input [2] or be based on behavioural change theory [4,6,7,8], factors considered important for apps to deliver positive health outcomes.

The Chief Medical Officer of England recently recommended Vitamin D supplementation for the whole population during the autumn and winter months [9]. Current uptake is known to be poor with potential risk to future health [10]. Mobile healthcare applications may be a useful source of information on Vitamin D usage for consumers and may increase uptake of supplements, provided the app incorporates appropriate dosing and product advice and is designed to help facilitate health professional discussion [11].

In this paper, we report findings from work undertaken to identify the Vitamin D apps currently available for consumer use, with evaluation for any beneficial outcomes including quality assurance for these apps, in order to improve the standard of healthcare delivery.

2. Aims

To identify and evaluate the number and quality of Vitamin D apps currently available for public use

3. Methods

This study incorporated a multi-phase mixed study design.

Phase one: Identification and categorisation. A search for Vitamin D apps available at one given point in time was undertaken on the Apple iOS and Android mobile smart-phones systems. Identified apps were categorised based on the proposed aims of app. Using the Delphi technique [12], this process involved the research team working towards interactive consensus with exchange of views and review of the apps by three members (NT, GO, MBl), with individual input at 3 stages to agree the final categories and categorisation of the Vitamin D apps.

Phase two: Research on use of apps and evaluation of outcome. A Medline, Embase and CINAHL databases search was undertaken using the following search terms; Vitamin D, Vitamin D deficiency, apps, smartphone / or computers handheld, rickets, mobile application / or Mobile apps / or Mobile phone / or mobile telephone and cell phones. Titles of the publications and abstracts if available were reviewed in line with study inclusion (use of apps and evaluation of outcome) and exclusion (not relevant to Vitamin D in particular) criteria, followed by assessment of full relevant papers. The search was extended to include Google Scholar using the search terms Vitamin D, rating scales and apps.

A validated mobile application rating scale was identified (MARS) [13]. Stoyanov et al [13] reported their work on developing the MARS in 2015, with testing by a multidisciplinary team comprising health professionals (health psychologists) and web developers, and with validation of the scale undertaken for apps used in the mental health field [13]. The MARS has also been used by other research teams, with intention to study the quality of apps in young adults with cancer [14] and in care delivery for patients with heart failure [15].

Phase three: Use of a modified validated rating scale to evaluate apps. The MARS [16] begins with initial data collection to classify the app enabling descriptive and technical information gathering for each app. This section includes identification of developer, version being assessed and purpose of the app as stipulated by the developer, affiliations, age group targeted by developer and technical supporting aspects, for example password protected access or a community discussion forum. The MARS team [16] state that some of these identifying data may need to be accessed via ITunes for the iOS systems or Google Play for the Android smart-phone apps. Within this classification section, data is also collected on focus of the app [what the app targets; with 12 criterion listed relating to mental healthcare provision, and option to record any additional relevant data under 'other'] and the theoretical background for the app, that is what strategies are supported by the app to enhance care delivery for the user.

Our research team discussed the background to the development of the MARS scale as described by Stoyanov et al in their publication [13], with decision to use the MARS to rate the Vitamin D apps, with scoring by three raters with a health professional background and experience of using mobile smart-phone apps as general members of the public [that is with no advanced information technology expertise]. The apps to be rated would be randomly allocated using the apps identified in the first phase of this study, and that rating of the Vitamin D apps would be under-pinned by view to deliver a high standard of healthcare to consumers looking for support for good bone health and good vitamin D levels. Criteria for data collection that were agreed under the 'focus' and 'theoretical background' sections therefore included:

1. 'Focus' of app: what the app targets (select all that apply): Increase Well-being; Behaviour Change; Goal Setting; Physical health; Other
2. 'Theoretical background'/Strategies (all that apply): Assessment; Feedback; Information/Education; Monitoring/Tracking; Goal setting; Other

The MARS scale [16] comprises a further 6 sections as follows: Section A focuses on engagement potential, that is, is the app fun to use, interesting, inter-active and well - targeted to audience? Section B focuses on functionality, with questions such as is the app easy to learn, use and navigate? Section C considers the aesthetics of the app including factors such as for example, design and overall visual appeal, colour scheme, and stylistic consistency. Section D focuses on the information provided by the app developer, with scoring for high quality information including text and feedback facilities, measures and references from a credible source. Raters are advised to select N/A if this app component was irrelevant, which indicates that the MARS development group [13] accepted that there would be poor quality information apps available to the public, but which may be aesthetically pleasing or where the primary purpose for the app may be entertainment or gaming.

Section E provided raters the option of scoring the app under test for subjective quality with section F looking at app-specific items. Section F criterion can be adjusted and used to assess the perceived impact of the app on the user's knowledge, attitudes, intentions to change as well as the likelihood of actual change in the target health behaviour.

After discussion within our research group, the decision was to score the Vitamin D apps identified in the first phase of this study using the MARS sections D, E and F criterion; with each health professional rater to spend between 5-10 minutes familiarising themselves by downloading and navigating the app under evaluation before rating the app for information quality - section D. It was also understood that to truly study for change in behaviour the app / apps would have to be tested with a consumer population; this was a limitation in our work as in our study each rater acted as a 'health professional' consumer to score the app.

The apps selected for scoring were those categories most relevant to health care provision. Scoring was undertaken by three research team members with a health professional background (NT, MBo, GO), with randomised allocation of the apps to be rated. MARS scores were allocated by each rater (n=3) for criteria validated for information quality (MARS section D) [16] and for criteria that supported subjective assessment to allow for the expected variation in individualised perspective on use of the smart-phone app (MARS section E and F) [16].

4. Results

With use of search term 'Vitamin D' on the Iphone iOS system smart-phone, a total of 51 apps were identified as available for use by interested members of the public, as either a free or chargeable resource. This was at one point in time with the search undertaken on 1st June 2016. The apps were categorised based on the proposed aim of the app (Table 1). Assessment of Vitamin D apps available to the public on the Android smart-phone system was then undertaken, with 21 apps identified on 28th July, 2016. The main purpose for use of the app was agreed by the research team using the Delphi technique [12] as described above.

Table 1 provides detailed information on the Vitamin D apps on the Iphone iOS system; these include advice on safe sun exposure (n=13), nutritional advice and support (n=19), commercial in orientation with provision of coupons towards purchase (n=3; system commonly used in the USA), apps which help with Vitamin D levels testing, tracking and guidance to help the user discuss the results with a doctor (n=6) and one app designed by a research institute and specifically targeting improvement in child health. 3 apps were designed to be used for educational purposes, for example in fields of chemistry and architecture with focus on the steroid structure of the Vitamin D molecule. 6 apps had been designed for the US leisure industry, and included general, simplified people oriented advice on safe sun exposure, exercise and relaxation treatments. The categories were found to be applicable for 17 of the 21 Android apps (Table 1), with 5 apps excluded, as one was in Chinese and the other four were not relevant.

In total, 51 and 21 Vitamin D apps were identified on the I-phone iOS and Android smart-phones respectively, available as a free or chargeable resource. Categories included: safe sun exposure (n=13; 6 respectively), nutritional advice and support (n=19;7), Vitamin D levels testing, tracking and for discussion with doctor (n=6;2). Some apps were designed for the US leisure industry (safe sun exposure, exercise, relaxation treatments) (n=6;1), for commercial use (n=3;1), with three iOS apps for educational utility (eg. chemistry, architecture). One iOS app had been developed to support delivery of child healthcare.

Those apps in the categories relevant to health care provision (shown in bold in Table 1; n=35) were then rated using the modified MARS. The MARS Information Quality scores ranged between 8 and 26 (see Table 2). The app for use exclusively by clinicians providing osteoporosis care scored highly at 26, with the Australian child health app assigned a score of 22. The remaining apps (n=7) focused mainly on advice to support dietary Vitamin D intake. One commercial app available on both the iOS and Android systems (MARS 20, 22 respectively), with these scores demonstrating good inter-rater consensus, targeted consumers with chronic conditions and supplementing with Vitamin D. MARS scores (Table 2) ranged from between 4 and 15 for subjective quality (Section E) and between 5 and 23 for App specific scoring (Section F).

Table 1. Vitamin D Apps available on Iphone iOS and Android systems

Information Category	No. apps - Iphone iOS	Iphone iOS Apps ID	Comments - Iphone iOS apps	No. apps - Android	Android Apps ID	Comments - Android apps
Sun exposure	13 apps	D MINDER PRO D VitaMeter **SunSmart** Vitamin D iTan Smart Free iTan Smart Sunbit Weather+D Violet by Ultra Vita Handling the Sun and Sunburn Naturally AYK Aus der Sonne Kraft fur den Kor	Free / purchased app French European	6 apps	D - Minder [free] Opti-D Time Calculator **SunSmart** [incorporating Vitamin D tracker] Vit D 30 [sun exposure vs cholesterol] Sun position Widget Violet	Paid version - see testing Sun exposure and cancer? Australian; Paid Information on sun angle
Vitamin D dietary angle	**19 apps**	**Vitamin D Calculator** **Vitamins and Minerals** **Absolute Healthy Diet** **Vitamin A and..** **Vitamin guide / dietary** **Nutrition journal for Iphone** **Vitamin D deficiency / personal remedies** **Vitamin in Food assistant** **2x2 Legend Flappy Fruit smasher / game element (Free; charged)** **Food4Bones / NOS app** **Vitamins-Minerals** **Nutricheck** **Calcium in foods** **A-Z Lebensmittel-Nahrwerte (Kcal….)** **GetNutrient** **VitaMind**	**Meal types, vitamins, sun exposure, daily total** **Game element** **NOS app** **European**	**7 apps**	**Vitamin Deficiency Finder** **Osteo Track** **Manage Osteoporosis** **Vitamine D (? Nutrition / Supplements)** **Vitamin D Deficiency** **Fontera Anlene Calcimeter** **Vitamins and Minerals Guide**	**Symptoms = food suggestions** **With exercise information / paid app** **Paid app** **Dubai app**

		Vitamin K – iNutrient **All iNutrient Apps** **Superhealthy – Nature Cures**				
Commercial	3 apps	Coupons for Vitamin Shoppe Coupons for Vitamin Emporium Bioceuticals		1 app	REMIND ME D3	Consilient pharmaco/ UK use only / support compliance with Vit D product
Testing, tracking and guidance to help d/w doctor	**6 apps**	**Vitamin-D Pro** **Calcium Pro** **NOF Clinicians guide to prevention and treatment of Osteoporosis / NOS supported app** **VitaStiq** **BioOsteo**	**'developed by Vitamin D and calcium doctors'; includes learning library** **For USA physicians / NOS supported app but FDA guidance based** **Skin testing?** **Bone marker levels tested**	**2 apps**	**D-minder** **Vitamin D pro**	**Both paid apps**
Children	**1 app**	**Vitality**	**Child health-developed by Murdoch Children's Research Institute / Australian**	-		
Education	3 apps	Steroids – Chemical Formulas Organic Chemistry PLD magazine [lighting design]	Chemistry Architecture	-		
Leisure Industry	6 apps	Stay Well Home Stay Well Meetings Stay Well Marriott Short Pump Stay Well Atlanta Marriott Stay Well MGM Grand Stay Well Lake Nona	For USA population	1 app	The Vitamin D Ride	

In bold - Mobile applications (apps) targeted for MARS (mobile applications rating scale) scoring
In red - Apps that have been evaluated / reported in the literature
Excluded Android apps: 5, as not relevant for search term Vitamin D and in English [App in Chinese; ASUS Splendid / screen saver modification app; SKETCH - Entertainment; Period Tracker - female menstrual cycle tracking app; S Health]
NOS: National Osteoporosis Society
NOF: National Osteoporosis Foundation
FDA: The US Food and Drug Administration.

Table 2. Vitamin D Apps dataset - Evaluation using MARS - with scoring for information quality and subjective quality score (see methods section, phase 3)

App name	MARS app classification criteria	Smart-phone app platform	Focus	Age group	Brief description	MARS Section D criteria / **Information Quality score**	MARS Section E **App Subjective Quality score**	MARS Section F **App Specific Rating score**
	V = version £ = sterling currency						For rater to consider - Recommend / use / purchase?	For rater to evaluate whether Supports attitude, or behaviour change?
National Osteoporosis Foundation (NOF) Clinicians Guide ....osteoporosis	V 1.0 Rating 4+ Updated 04.05.13 Free for clinicians English	iOS	Osteoporosis education / for clinical utility	Adults	Clinician guide / USA Food and Drug Administration based advice	26	13	22
Vitamin D calculator	V 3.4 Rating 4+ Updated 28.06.14 Free app English	iOS	Behavioural change; Goal setting; Physical health; Diet; Guidance to speak with health professional;	General	...to assist you in estimating your daily intake of Vitamin D and Calcium....foods, multivitamins and casual sun exposure	25	12	21

			Other - Rickets, Bone Health					
Vitamin D-Pro / commercial	V 1.0.1 Rating 4+ Updated 30.01.14 App £1.49 English	iOS	Physical health	Adults	App will analyse and graph all aspects of your Vitamin D and Calcium health and make personal recommendations	23	12	21
D Vitality	V 1.1b1 Rating 12+ Updated 27.2.15 Free app English, Australian	iOS	To assist parents with reminder for daily administration Vitamin D drops to children	Children and adolescents / Carers	Reminder tool for parents administering daily Vitamin D drops to their children	22	8	23
Vitamin D Deficiency / commercial	V 2.6 Rating 12+ Updated 16.06.16 App £2.29 English	iOS	Behavioural change; Lifestyle modification ; Diet	General	Individualised dietary guidance for patients with chronic conditions on Vitamin D	20	12	7
Vitamin D Deficiency / commercial	V 2.6 Unrated Updated 10.06.16 App £1.97 English	Android	As above	Adults	Comprehensive nutrition guide	22	15	21
Vitamin D Deficiency finder	V 2015 Unrated Updated 2015 Free app English	Android	Input symptoms and get information on required nutrients / foods	Adults / General	4 files - deficiency finder; food suggestions; vitamin D details; profiles and reports.	17	8	17
Osteo track Manage Osteoporosis	V 1.0.1 Unrated Updated 29.08.13 App £1.76 English	Android	Lifestyle changes to help strengthen bones; Goal setting	Adults / General	The osteoporosis and osteopenia management app - get guidance on bone building nutrients and exercises	15	8	21
Nutricheck	V 3.5.3 Rated 4+ Updated 31.08.16 App £2.99 English + 46 other languages	iOS	Diet; Behavioural change	Adults	Designed to help you buy healthier food products; calorie content and nutrients in diet	15	8	5
Vitamins and Minerals	V 2.2.5 Rated 4+ Updated 20.08.14 Free app English	iOS	Diet	Adults	Improve your diet, health and beauty with more knowledge about vitamins and minerals	8	4	8

Notes:
Rating 12 + stated for some apps and coded as for 'infrequent / mild and medical / treatment information'; 2 apps (22%) identified as used for medical healthcare delivery - in yellow above and 78% (7/9) apps with lifestyle focus.

Table 3. Vitamin D smart-phone apps, evaluated for stated outcome and reported in the literature

Publication	Name for mobile app	Availability	Outcome tested for ?	Author comments	Reference	Category
1	**'The bone thief'** <u>Aim</u>: Raise awareness and develop good habits of life	Apple iOS and Android	Development of app and content with brainstorming and phone conferences; included patient advisors and experts App designed and reported as available at conference	Osteoporosis risks First French mob app Partnership with Yoplait Proactive notifications / use as a e-coach. Several headings inc choosing diet rich in Calcium and Vitamin D; exhibition the sun; weekly	Ann Rheu Diseases 2015;74:1358-59	Osteoporosis and fracture risk / for patient to discuss with doctor - nutrition - sun exposure

			Vitamin D outcome specifically not tested for	physical activity		
2	**Vitamin D calculator app** [2 abstracts]		Validity and reproducibility of dietary component of mobile vitamin D calculator app Mean vitamin D and calcium intake and risk classifications did not differ significantly between the 2 measures - app and dietary recalls	Valid classification measure for dietary vitamin D and calcium intake Canadian adults Tool could be used by general public to increase awareness and intake of nutrients	Goodman S, et al 2015;47:242-7	Nutrition
3	**Solar Cell** Aim: real time sun protection advice	Android smart-phone	Randomised control trial design n=202; volunteer sample Use of mobile app -percentage days with use of sun protection; time spent outdoors in midday sun; number of sunburns in last 3 months	Use of mob apps to communicate large amounts of real time health advice Strategies to increase use of mob apps needed for effective deployment in general adult population	Buller DB, et al. JAMA Dermatology 2015;151:505-512	Sun exposure / protection
4	[**Solar Cell]** Aim: real time sun protection advice	Android smart-phone	Randomised control trial pre-test post-test controlled design with 10 week follow up. N=604 Use of mobile app - percentage days with use of sun protection; time spent outdoors in midday sun; number sunburns in last 3 months No significant difference in number sunburns in past 3 months	Mobile app improved some sun protection Use of mobile app lower than expected; associated with increased sun protection	Buller DB, et al. JAMA Dermatology 2015;151:497-504	Sun exposure / protection
5	**SunSmart** Aim: Communicate ultra-violet (UV) radiation information via app -translate UV exposure into an easy to understand useful tool; call for action; inform daily decisions for sun exposure	Iphone and Ipad; Android, Samsung	Research - to inform app development; quantitative and qualitative evaluation to assess use, perceptions, behavioural intentions associated with app / 87% users said app met or exceeded expectation; 86% agreed app made them more aware of times for sun protection; more than half refer to app daily. Qualitative research - how people use apps and for future updates	Australian Extension of international standard Global Solar UV Index Includes Vitamin D tracker; Sunscreen calculator Paid / unpaid media to promote app Challenge identified - update and refresh app	Dunstone K & Wakely L. Asia-Pacific J Clin Onco 2014; 10: 7743-55	Sun exposure / protection
6	**Solar Cell** Aim: real time sun protection advice	[Android smart-phone]	Focus groups / proof of concept. 4 rounds of usability testing to develop interface for SolarCell Findings: adults desired sun protection advice; identified few barriers to use; willing to input personal data	User centred production of mob app for sun protection	Buller DB et al Translational Behav Med 2013;3:326-334	Sun exposure / protection

			Usability testing / interoperable across handsets and networks Highly user friendly			
7	Work towards developing the **Nutriphone**, a comprehensive system of analysis of multiple vitamins and micronutrients on smartphone		Comparison of app system with well established ELISA test kits for serum samples Accurately measures 25 hydroxy Vitamin D levels - accuracy better than 15 nanomolesand precision of 10 nanomoles.	Rapid quantification of Vitamin D levels on a smartphone Need Smartphone accessory, an app, test strip.	Seoho l, et al. Lab on a chip 2014;14(8) :1437-1442	Vitamin D testing

5. Discussion

People interested in changing their health behaviour are downloading and purchasing commercially developed lifestyle and or healthcare computer software. This is facilitated by the increase in technologically advanced, often elegantly designed, small screen portable in-built computerised systems on mobile smart-phones.

A recent European wide survey [3] showed large variation in medical electronic devices and apps used by young professionals working in the field of radiation oncology. The researchers commented on the importance of verifying the consistency of information found within apps, to help avoid potential errors that could eventually prove to be detrimental for patients. The recommendation was that specific quality assurance criteria be developed for medical apps, including the suggestion that a comprehensive web site for all reliable applications and tools, which might be useful for daily clinical practice, be compiled. Authors also suggest [2,5] that apps associated with good quality content are those that have been developed by or are linked with a medical professional. Edlin and Deshpande [2] identified inadequate input from the medical profession in their study, and highlight the urgent need for quality evaluation, regulation, and information security, which they state is required for smart-phones and handheld devices for these to become an integral and safe part of delivery of health care. Most work reported under the research theme utilise clinical input and adherence with evidence based guidelines and or practice to support quality content, with researchers identifying other relevant issues that need to be considered for effective and appropriate use of apps [7].

Measures or criteria necessary for high quality health apps include content quality, accuracy and reliability, links to clinical input and evidence based guidelines or practice, app validation under real world conditions, the addressing of technical quality (eg. functional bugs; patient consent), and behavioural and strategy index scoring to allow for measurement of change in healthcare behaviour which hopefully will be on a positive health outcome trajectory.

Turning to Vitamin D specific apps , a French research team [17] supported by Yoplait (www.yoplait.com), have developed an app that provides the public with information to help them work out their risk for osteoporosis and fracture and which they could use to have a discussion with their GP. The aim stated for the development of this app, the **'Bone Thief'**, is to raise awareness and develop good life habits. A system designed to be self utilised as an electronic coach, the app comprises several headings including choosing a diet rich in Calcium and Vitamin D, exhibition [exposure] to sun and weekly physical activity. Although developed for both the Apple iOS and Android platforms, this particular app was not identified with the search term Vitamin D when assessment of app availability was checked at the time points for our research in the first phase. This could be because the app provides information on the osteoporosis condition per se, and is still in the development stage. There were two apps identified that had similar objectives to the **'Bone Thief'**, called the **Food4Bones** app and the **NOF Clinicians guide to prevention and treatment of Osteoporosis** (Table 3). Both these apps are supported by the UK's National Osteoporosis Society, but no beneficial outcomes evaluation has been published in relation to these two apps. The learning reported [17] considered the process for development which included brainstorming sessions between experts and patient advisors to agree content, but there were no other condition or disease related outcomes studied.

Buller et al have published their work [18,19,20] reporting on the development of the app **Solar Cell**, designed for the Android smartphone, and where the aim is to provide real time sun protection advice. The pilot stage included the running of focus groups for conceptual determination [18], followed by four rounds of usability testing to develop the app interface. This work found that adults desired sun protection advice, they identified few barriers to app use and were willing to input personal data. Further research [19] included a randomised controlled trial pre-test post-test design with 10 week follow up for usability testing and to assess if the system was interoperable across handsets and networks. The system was found to be highly user friendly with a mean of 5.06 (Range 0 = worst imaginable to 7 = best imaginable) [20]. With regards to Vitamin D related outcomes, the research for the **Solar cell** app found that it helped with some improved sun protection. Use of the app was lower than expected. When utilised, it was associated with increased sun protection but with no significant difference in number of sunburns in the past 3 months from point of study. The research team commented [18,19] that strategies to increase use of mobile apps would be needed for more effective deployment in the general adult population.

The Australian **SunSmart** app was identified on the iOS system and has been evaluated [21]. This app was developed with the aim of communicating complex UV light and frequency exposure information via an easy to use tool to help with daily decisions around safe sun exposure. Initially developed for the iOS Iphone and Ipad systems, the app is now available also on the Android and Samsung platforms. Essentially an extension of the international standard Global Solar UV Index, the app also includes Vitamin D tracker and sunscreen calculator functions. Paid and unpaid media were utilised to promote the app. 87% users said that the app met or exceeded their expectation with 86% agreeing that the app made them more aware of times for sun protection. More than half of app users said that they referred to the **SunSmart** app daily. No further objective beneficial outcomes have been reported. The research team note that the ongoing challenge is with need for regular updates and refreshing of the app [21].

Research undertaken to study the validity and reproducibility of the dietary component of a mobile **Vitamin D calculator** app [22] found that the mean vitamin D and calcium intake and risk classifications did not differ significantly between the 2 measures studied, namely real time information input into the app versus dietary recalls. Goodman et al [22] suggest that this app would be a good tool for use by the general public to help increase both the awareness and intake of nutrients. Interestingly work on the **Nutriphone** app where the aims are to develop a comprehensive system of analysis for multiple vitamins and micronutrients on the smart-phone has involved comparison of the app system with the well-established ELISA test kit for serum samples [23]. With a smart-phone accessory, an app, and a test strip, the system is reported to accurately measure 25- hydroxy vitamin D levels, with an accuracy better than 15nM and precision of 10nM, thus allowing for rapid quantification of Vitamin D levels on a smart-phone device.

In summary no Vitamin D app was identified where evaluation in research trial settings has shown significant beneficial health outcomes. All the apps discussed above are at the development stage at present. Our study had some limitations. Our research aimed to identify Vitamin D apps available on the iOS and Android systems and this was at one point in time. However it is accepted that development and availability of apps is increasing at a fast pace and with time. Our work did not identify any good quality Vitamin D app per se for consumer use that would support supplement choice and dosing. What is apparent is that the criteria necessary for high quality health apps which researchers consider important include content quality, accuracy and reliability, links to clinical input and evidence based guidelines or practice, app validation under real world conditions, the addressing of technical quality and behavioural and strategy scoring to allow for measurement of change in healthcare behaviour. These criteria help to form a checklist for any potential future development of a Vitamin D app for consumer use.

Using a mobile applications rating scale, MARS [13,16], we identified 9 apps that supported a reasonable level of healthcare delivery. However considering 2 of these apps, one was specifically designed for use by clinicians in the USA to support osteoporosis patient health care delivery, and therefore is not available for general consumer use. The second app has been developed by a research unit in Australia, for use by parents of sick children needing daily administration of Vitamin D, incorporating reminder texts and which facilitates ongoing support from their specialist centre health professional team. The remaining 7 Vitamin D apps assigned a MARS score focused primarily on Vitamin D nutritional support.

6. Conclusion

There were no high quality Vitamin D apps identified for use by consumers to help decision on routine Vitamin D supplementation. With significant number of people currently vitamin D deficient and at risk of its complications, a validated mobile app for healthcare delivery should be developed. Multi-disciplinary, public and health professional involvement will be necessary to ensure quality of the app, and to optimize safety and efficacy when utilized for healthcare delivery. The Vitamin D app will need regular updating with time. Our group are the first to use a modified mobile apps rating scale (MARS) with focus mainly on assessing the quality of information. In the future health apps should be assessed and rated routinely for quality of information, so consumers know they can trust the health information being provided.

References

[1] Speidel D, Sridharan M. Quality assurance in the age of mobile healthcare. *The Journal of mHealth* 2014; 1(2):42-46.

[2] Edlin JC, Deshpande RP. Caveats of smartphone applications for the cardiothoracic trainee. *J Thorac Cardiovasc Surg*. 2013 Dec; 146(6): 1321-6.

[3] De Bari B, Franco P, Niyazi M, Cornetto AP et al. The Pocketable Electronic Devices in Radiation Oncology (PEDRO) Project: How the Use of Tools in Medical Decision Making is Changing? *Technol Cancer Res Treat*. 2016 Apr; 15(2):365-76.

[4] Abroms LC, Lee Westmaas J, Bontemps-Jones J, Ramani R, Mellerson J. A content analysis of popular smartphone apps for smoking cessation. *Am J Prev Med*. 2013 Dec; 45(6):732-6.

[5] Workman AD, Gupta SC. A plastic surgeon's guide to applying smartphone technology in patient care. *Aesthet Surg J*. 2013 Feb; 33(2): 275-80.

[6] Ryan P, Maierle D, Csuka M E, Thomson A, Szabo A. Computer based intervention to enhance self-management of calcium and vitamin D intake in women. *West J Nurs Res* 2013; 35(8): 986-1010.

[7] Wearing JR, Nollen N, Befort C, Davis AM, Agemy CK. iPhone app adherence to expert-recommended guidelines for paediatric obesity prevention. *Child Obes*. 2014 Apr; 10(2):132-44.

[8] Kervick AA, Hogan MJ, O'Hora D, Sarma KM. Testing a structural model of young driver willingness to uptake Smartphone Driver Support Systems. *Accid Anal Pev* 2015 Oct;83: 171-81.

[9] Scientific Advisory Committee of Nutrition. Vitamin D and Health. Public Health England Crown Copyright 2016. Report available at: https://www.gov.uk/government/groups/scientific-advisory-committee-on-nutrition (accessed 25th January, 2017).

[10] Spector T, Levy L. Should healthy people take a Vitamin D supplement in winter months? *BMJ* 2016;355:i6183.

[11] Michie C. How to reduce the risks associated with Vitamin D self-supplementation. *Clinical Pharmacist* 2016; 8(5).

http://www.pharmaceutical-journal.com/opinion/correspondence/no-guarantee-of-quality-with-unlicensed-vitamin-d-products/opinion/insight/how-to-reduce-the-risks-associated-with-vitamin-d-self-supplementation/20201085.article.
[12] Dick, B. (2000). Delphi face to face [On line]. Resource Papers in Action Research. Available at http://www.uq.net.au/action_research/arp/delphi.html (accessed 25th January, 2017).
[13] Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. *JMIR mHealth uHealth* 2015; 3(1): e27).
[14] Pugh G, McCann L. Assessing the Quality, Feasibility, and Efficacy of Electronic Patient Platforms Designed to Support Adolescents and Young Adults With Cancer: A Systematic Review Protocol. *JMIR Res Protoc* 2017; 6(1): e4.
[15] Masterson Creber R M, Maurer M S, Reading M, Hiraldo G, Hickey K T, Iribarren S. Review and Analysis of Existing Mobile Phone Apps to Support Heart Failure Symptom Monitoring and Self-Care Management. Using the Mobile Application Rating Scale (MARS). *JMIR Mhealth Uhealth* 2016; 4(2): e74.
[16] Multimedia Appendix 2 Mobile App Rating Scale. [PDF File (Adobe PDF File), 259KB- mhealth_v3i1e27_app2.pdf] in Stoyanov SR et al 2015. (accessed 25th January, 2017).
[17] Dachicourt JN, Poivret D, Bonnet C, Chales G, Alliot-Launois F, Carton L, Grange L. Mobile Apps “The Bone Thief”, First Electronic Application On Ostoporosis. *Ann Rheu Diseases* 2015; 74: 1358-59.
[18] Buller DB, Berwick M, Lantz K, Buller MK, Shane J, Kane I, Liu X. Evaluation of immediate and 12-week effects of a smartphone sun-safety mobile application: a randomized clinical trial. *JAMA Dermatology* 2015; 151: 505-512.
[19] Buller DB, Berwick M, Lantz K, Buller MK, Shane J, Kane I, Liu X. Smartphone mobile application delivering personalized, real-time sun protection advice: a randomized clinical trial. *JAMA Dermatology* 2015;151:497-504.
[20] Buller DB, Berwick M, Shane J, Kane I, Lantz K, Buller MK. User-centered development of a smart phone mobile application delivering personalized real-time advice on sun protection. *Translational Behav Med* 2013; 3: 326-334.
[21] Dunstone K & Wakely L. There is an app for that! Communicating UV via the Sunsmart app. *Asia-Pacific J Clin Onco* 2014; 10(S9): 1-264.
[22] Goodman S, Morrongiello B, Randall Simpson J, Meckling K. Vitamin D intake among young Canadian adults: validation of a mobile vitamin D calculator app. *J Nutr Educ Behav* 2015; 47: 242-7.
[23] Lee S, Oncescu V, Mancuso M, Mehta S, Erickson D. A smart-phone platform for quantification of Vitamin D levels. *Lab on a chip* 2014; 14(8): 1437-144.