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The development and usability of a web-based mobile application as a dairy intake screener for South African adults

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Research Article

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Abstract

Paper-based dietary assessment tools such as food frequency questionnaires (FFQ) and especially dietary screeners are making way for versions that use technology. Amidst low intakes of dairy and dairy-related nutrients in South Africa, and to increase public awareness thereof, we aimed to develop and evaluate the usability of an application (app) to screen for dairy intake in higher income South African adults. In a consultative process, a dairy intake screener ('Dairy Diary') was developed as an eight-item quantitative FFQ with four types of commonly consumed local dairy products: milk, maas (fermented milk), yoghurt, and cheese. For each dairy product, usual frequency of consumption and portion size per eating occasion were scored resulting in three risk classes: <1 serving daily; 1≤2 servings daily; ≥2 servings daily. Digitalisation included product- and portion-specific graphics with linkage to risk class-relevant preliminary dairy-related guidance as part of a web-based mobile app. For the evaluation of the usability, the 26-item end-user version of the Mobile Application Rating Scale (uMARS) was used in an online cross-sectional survey (Qualtrics; April 2020). Items were scored on a 5-point Likert-type scale, resulting in three final app scores. From a conveniently recruited sample of 1102, 703 (64%; 81% female; mean age 29.8 ± 11.0 years) were retained for analysis. uMARS-informed descriptive statistics summarise the findings. The uMARS app mean objective quality score (3.9 ± 0.85), app subjective quality score (3.5 ± 0.77), app-specific score (3.6 ± 0.94), and additional question on e-portion (4.3 ± 0.78) met the minimum acceptability score of ≥3.0. For the subscales, the mean score for aesthetics was the highest (4.4 ± 0.82), followed by information (4.3 ± 0.90) and functionality (4.0 ± 1.33). Engagement scored lowest (3.0 ± 1.55). The 'Dairy Diary' is a user-friendly screener for dairy intake.

In South Africa, dairy intake is low (Labadarios *et al.*, 1999; Mchiza *et al.*, 2015) and does not meet the daily recommendations as per the South African food-based dietary guidelines (Vorster *et al.*, 2013). Available evidence suggests a beneficial role of dairy in managing non-communicable diseases (such as heart disease and diabetes: Thorning *et al.*, 2017; Aljuraiban *et al.*, 2019; Guo *et al.*, 2019; Bhupathi *et al.*, 2020), in contributing to meeting gap nutrient intakes (Weaver, 2014), and in being a surrogate marker of diets higher in nutritional quality (Clerfeuille *et al.*, 2013; Rice *et al.*, 2013; Weaver, 2014).

Dietary screening (a short, focused, preliminary assessment of intake) is popular when information on total diet is not needed and when financial and/ or time constraints are applicable (Gurinovic *et al.*, 2017). Dietary screening may create awareness of poor intake, triggering a comprehensive dietary assessment (Field and Hand, 2015) and thus intervention by a nutrition professional. The food frequency questionnaire (FFQ) is a dietary assessment tool that assesses how often food items from a predetermined list are usually consumed within a specified reference period (Rodrigo *et al.*, 2015). In the quantitative version, portion sizes of the foods are also determined. Traditionally, dietary assessment tools were paper-based, but increasingly these are making way for technology-based versions in the form of web- and mobile-based applications (apps): software apps that can be executed (run) on a mobile platform (with or without wireless connectivity) or a web-based software app tailored to a mobile platform but executed on a server (U.S. Department of Health and Human Services, 2015).

The underlying methodology of dietary assessment is unchanged by technology (Sharp and Allman-Farinelli, 2014; Illner *et al.*, 2012), yet technology offers the potential of improved efficiency (Hongu *et al.*, 2011; Burrows and Rollow, 2019). Compared to traditional versions, a greater preference and satisfaction to use technology-based versions have been reported (Touvier *et al.*, 2011; Sharp and Allman-Farinelli, 2014; Hutchesson *et al.*, 2015; Timon *et al.*, 2017; Torre *et al.*, 2017; Burrows and Rollow, 2019). Flexibility, ease of access, reduced respondent burden, increased respondent co-operation, compliance, acceptance and greater appeal and relevance to a younger population are some of the strengths of web- and mobile-based apps (Hongu *et al.*, 2011; Gurinovic *et al.*, 2017; Illner *et al.*, 2012). Limitations include

high development and set up costs, the need for secure internet access and limited use in populations that are not familiar with technology, such as the elderly (Gurinovic *et al.*, 2017).

The initial evaluation of a dietary screener is typically in terms of usability: the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use (ISO, 1998). There is no consensus on the best tool to assess usability of mobile apps. The Mobile Application Rating Scale (MARS) (Stoyanov *et al.*, 2015) is a simple, objective tool to critically appraise the quality of health-related apps. Because MARS requires some training and expertise, a user-friendly version, the uMARS (Stoyanov *et al.*, 2016) was developed with excellent internal consistency ($\alpha = 0.90$) and high α for all subscales (engagement $\alpha = 0.80$; functionality $\alpha = 0.70$; aesthetics $\alpha = 0.71$; information $\alpha = 0.78$; satisfaction $\alpha = 0.78$). The total uMARS score and each individual subscale also have good test–retest reliability (Stoyanov *et al.*, 2016).

Accordingly, the first objective of this study was to develop a web-based mobile app ('Dairy Diary') as a tool to screen for dairy intake in South African adults, and the second objective was to evaluate the usability of the 'Dairy Diary' in two high income subgroups (consumers and nutrition professionals) using uMARS.

Materials and methods

The content and design of the dairy screener were compiled, reviewed, and revised in a consultative process by a working group of dietitians and nutritionists knowledgeable in consumer education related to dairy and/ or dietary assessment. The dietary screener is available online at the Consumer Education Project (CEP) of Milk South Africa (https://www.dairygivesyougo.co.za/dairy-diary)

Study design, population and sample, data collection tools

In a cross-sectional e-survey, data were collected by means of an online questionnaire (via Qualtrics). The population were South African adults (consumers and nutrition professionals) of high income (living standards measure, LSM, >8) aged 19–65 years with access to a computer and/or smartphone and internet. The LSM (http://www.eighty20.co.za/lsm-calculator/) is a widely used socioeconomic segmentation tool in South Africa for classifying consumers independent of race/ethnicity, sex, age or any other variable. Recruitment took place between March and April 2020. Participants were conveniently sampled *via* word of mouth and social media platforms associated with the University of Pretoria, professional dietetics and nutrition associations in South Africa (such as the Association for Dietetics in South Africa [ADSA]), and the Consumer Education Project (CEP) of Milk South Africa website ('Dairy Gives You Go').

First, participants completed the 'Dairy Diary' which calculates a daily serving score. Second, participants evaluated the 'Dairy Diary' using uMARS, with an additional question on portion sizes in an electronic format (e-portions) added. The uMARS (Stoyanov *et al.*, 2016) consists of 26 questions of three scores: app objective quality (four sub-scales of 16 items including 5 items on engagement, four on functionality, three on aesthetics and four on information), app subjective quality (four items) and app-specific score (six items adjusted to include questions to assess the perceived impact of the app on the user's knowledge, attitudes and intentions to change for the target health behaviour, i.e. dairy intake). Information on demographics (age, self-reported weight and height to calculate body mass index (BMI), gender), perceived health status and mobile app usage was collected. For nutrition professionals, additional information included recommended use of apps to patients, area of practice, reason for recommending app usage and opinion on the use of mobile apps compared to traditional (paper-based) methods for dietary assessment. A pilot study was conducted before commencement of data collection on eight participants (two nutrition professionals and six consumers), the participants of which were not included in the final analysis.

Data management and statistical analysis

Raw data were exported from Qualtrics in Microsoft Excel format. Data were cleaned for incomplete and/or missing responses, those with LSM <8 and those without informed consent. To calculate BMI, self-reported weight (kg) was divided by self-reported height (m) squared. Descriptive statistics of central tendency (means) and dispersion (SD and 95% CI) were applied for demographic information, the daily serving score and uMARS data. For the latter, all items were scored on a 5-point Likert-type scale (1 = inadequate; 2 = poor; 3 = acceptable; 4 = good, 5 = excellent; N/A = not applicable). Mean scores per item were reported instead of total scores as items may be rated as not applicable. The minimum mean acceptability score for the uMARS was ≥3.0 (Mani *et al.*, 2015). Data analyses were performed using Stata Release 15 (Release 15.1, College Station, TX: StataCorp LLC).

Ethical approval

The study was approved by the University of Pretoria Faculty of Health Sciences Research Ethics Committee (705/2018). Electronic informed consent was obtained, and all information was confidential. Participants voluntarily provided contact details to enter a random lucky draw to receive one of three online vouchers.

Results

Results of this study are described using the International Life Sciences Institute (ILSI) Europe Dietary Intake and Exposure Task Force Best Practice Guidelines (Elridge *et al.*, 2019) for reporting on dietary intake assessment tools using new technologies. Steps 1–4 are used for the development and step 5 for the usability of the dairy intake screener.

Step 1: purpose of the tool

The main purpose of the 'Dairy Diary' is to screen for and identify consumers at risk of low dairy intake. The dietary screener is for direct consumer use. South African adult consumers of higher income and nutrition professionals were the primary target group in this study.

Step 2: main measurement features of the tool

A quantitative FFQ format was chosen for the 'Dairy Diary'. Participants were prompted to consider habitual dietary intake of dairy products, usually consumed as a snack or meal, eaten at or away from home and/ or eaten alone or as part of a meal over the previous month. Assisted data entry allowed the user

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to select frequency of consumption and portion size from predefined options. Additional items could not be entered into the 'Dairy Diary'. For each dairy product, customisation included visual representation of portion sizes (eg cup measures for milk, maas, a widely consumed fermented milk in South Africa, yoghurt and soft cheese but slices for hard cheese), supplemented with text indicating various ranges in volumes and cup measures (up to ½ cup, ½–1 cup, more than 1 cup) (online Supplementary Fig. S1). The user was able to return to previous screens, as necessary. Once digitalised, graphic enhancement was added. No further supplementary information on physical activity or dietary supplementation was collected.

Step 2: main measurement features of the tool: food list

The food list is the backbone of the FFQ (Cade *et al.*, 2004; Shim *et al.*, 2014). Three dairy products specified in the relevant South African food-based dietary guideline ('*Have milk, maas and yoghurt every day*') (Vorster *et al.*, 2013), plus cheese, all represented generically, formed the four dairy products and basis of the FFQ. Additional data were collected about the form of dairy product consumed: milk (reduced fat or full cream), maas (reduced fat or full cream), yoghurt (plain or flavoured), and cheese (hard or soft) (online Supplementary Fig. S1). This resulted in a final food list of eight items.

Step 2: main measurement features of the tool: frequency score

For each dairy product, the frequency (number of times) of consumption was assessed in four frequency categories: never, per day (0–3 times), per week (1–6 times), or per month (1–3 times). Each frequency category was converted into a daily intake amount. To score daily intake amounts, the frequency per day was defined by a factor of 1 (ie if the user indicated drinking milk twice a day, the factor is 2/1). To score weekly amounts, the frequency per week was defined by a factor of 7 (ie if the user indicated eating yoghurt three times per week, the factor is 3/7). To score monthly amounts, the frequency per month was defined by a factor of 30.417: the average number of days per month in a calendar year (ie if the user reported consuming maas twice per month, the factor is 2/30.417).

Step 2: main measurement features of the tool: serving score

The portion size consumed per eating occasion for each dairy product was shown as text and with quantifiable graphics, indicated as 'little', 'medium', or 'lots', defined as 50%, 75%, and 100% or more of a reference serving, respectively. The CEP of Milk SA defines the reference serving size of dairy as an amount containing 300 mg of calcium. For milk and maas, portions were scored as 0.5 for intake up to ½ cup, 0.75 for intakes ½–1 cup, or 1.0 for intakes more than 1 cup. For yoghurt, portions were scored as 0.5 for intakes of 1 small tub (100 ml), 0.75 for intakes of 1 cup, or 1 for intakes of more than 1 cup. For hard cheese, portions were scored as 0.5 for 1 slice (up to 20 g), 0.75 for 2 slices (20–40 g), or 1.0 for 3 slices (more than 40 g). For soft cheese, portions were scored as 0.5 for up to ¼ tub (60 g), 0.75 for ¼–½ tub (60–125 g), or 1.0 for intakes of more than 1 tub (125 g) (Table 1).

Step 2: main measurement features of the tool: daily serving score

A dairy product score was calculated for each dairy product by multiplying the frequency score by the portion score. The daily

Table 1. Calculations underpinning the daily serving score

Dairy product	Items in Dairy Diary	Method of eating/drinking	Frequency score: A[a] How often per day?					Serving score: B How much per eating occasion?			Dairy product[b] score = AxB
			Never	Per day	Per week	Per month		Little (Serving score: 0.5)	Medium (Serving score: 0.75)	Lots (Serving score: 1.0)	
Milk	Reduced fat[c] Full cream	As a drink on its own	0	Once: 1/1 Twice: 2/1 Three times: 3/1	Once: 1/7 Twice: 2/7 Three times: 3/7 Four times: 4/7 Five times: 5/7 Six times: 6/7	Once: 1/30.417 Twice: 2/30.417 Three times: 3/30.417		Up to ½ cup	½–1 cup	>1 cup	1
		In tea and coffee	0					<30 ml	30–50 ml	>50 ml	
		Cereal/porridge	0					<½ cup	½–1 cup	>1 cup	
		Flavoured milk	0					<½ cup	½–1 cup	>1 cup	
		Milky dessert e.g. custard	0					<½ cup	½–1 cup	>1 cup	
Maas	Reduced fat;[c] full cream	N/A	0					<½ cup	½–1 cup	>1 cup	2
Yoghurt	Flavoured; plain	N/A	0					1 small tub (100 ml)	1 cup (200–250 ml)	>1 cup (250 ml)	3
Cheese	Hard	N/A	0					1 slice (<20 g)	2 slices (20–40 g)	3 slices (>40 g)	4
	Soft	N/A	0					<¼ cup (60 g)	>½ tub (60–125 g)	>1 tub (125 g)	
Daily serving score[d]											= 1 + 2 + 3 + 4

[a]Reported frequency of intake converted to intake per day. Examples: To score *daily* amounts, the reported frequency of intake per day was divided by a factor of 1 (i.e. if the user indicated drinking milk twice a day, the daily amount is 2/1). To score *weekly* amounts, the reported frequency of intake per week was divided by a factor of 7 (i.e. 7 d per week i.e. if the user indicated eating yoghurt three times per week, the daily amount is 3/7). To score *monthly* amounts, the reported frequency of intake per month was divided by a factor of 30.417: the average number of days per month in a calendar year (i.e. if the user reported consuming maas twice per month, the daily amount is 2/30.417).
[b]Dairy product score: for each dairy product, frequency score (A) multiplied by serving score (B).
[c]Includes fat-free and low fat.
[d]Daily serving score: sum of the dairy product scores (1–4).

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Table 2. The daily serving score[a] of the study participants ($n = 703$)

Dairy product	Mean intake[a]	SD[b]	Min	Max	95% CI[c]
Milk	1.00	0.74	0.0	4.71	0.95–1.06
Maas	0.10	0.21	0.0	2.50	0.48–0.80
Yoghurt	0.41	0.51	0.0	3.75	0.38–0.45
Cheese	0.53	0.55	0.0	3.67	0.49–0.57
Daily serving score[d]	2.01	1.37	0.0	14.64	1.91–2.11

[a]Mean intake :Average dairy product score for sample ($n = 703$).
[b]SD: standard deviation.
[c]CI: confidence interval.
[d]Daily serving score: sum of the four dairy product scores, calculated for each dairy product by multiplying frequency score by portion score.

serving score was the sum of the dairy product scores (Table 1). The daily serving score was classified into three risk classes (<1 serving daily, 1≤2 servings daily, or ≥2 servings daily), guided by recommendations to consume at least 2 servings of dairy per day (Weaver, 2014). Maximum actual products serving scores for milk, maas, yoghurt, cheese and the daily serving score were 4.71, 2.50, 3.75, 3.67 and 14.64, respectively (Table 2). The theoretical maximum daily serving score was 24.47.

Step 3: platform/technology of the tool

The final content was converted to a digital version, executed on a web browser from an internet-connected device such as a smartphone, tablet, laptop, or computer. This platform was deemed appropriate for the population as data costs in South Africa are high, which may deter users from downloading the screener in a mobile app format. The development costs of a mobile app were another consideration.

Step 4: customisation features of the tool

A predetermined list of local dairy products with household measures (supplemented with images) form the basic customisation features of the screener (online Supplementary Fig. S1). Feedback included preliminary nutritional education ('Dairy Tips') linked to the participant's daily serving score. This consisted of consumer-friendly, targeted dairy-related information to support and encourage increased dairy intake or to maintain current intake. No further customisation features were available.

Step 5: evaluation of the usability of the 'Dairy Diary' with uMARS: description of sample

In total, 1102 responses were received. From these, a complete data set was available for 703 (64%) participants (online Supplementary Fig. S2). The majority of participants ($n = 573$; 82%) were consumers whereas the remaining 130 were nutrition professionals. The participants had a mean ± SD age of 29.8 ± 11.0 years and BMI of 24.9 ± 5.2 kg/m^2. The majority of participants (81%) were female and more than half (57%) had a healthy BMI (18.5–24.9 kg/m^2). Approximately one-third of the participants (32%) heard of the 'Dairy Diary' through contacts at the University of Pretoria and almost all (95%) had completed the 'Dairy Diary' for the first time, many of them (54%) on a smartphone. More than two-thirds (68%) of participants reported being 'very healthy' and 22% reported using nutrition- or health-related apps 'daily (or mostly daily)' (Table 3).

Almost all (99%) of the nutrition professionals were female and many (46%) worked in private practice, with 60% of these recommending nutrition- and health-related apps to their patients/clients. The most common reason for recommending the use of an app included 'for patient self-monitoring' (50%), 'to increase awareness' (41%), and 'for motivation and extra

Table 3. Demographic and background information of the study participants ($n = 703$)

Background characteristics[a]			n	%
Sex	Female		568	80.8
	Consumer ($n = 73$)	Female	440	76.8
	Nutrition professional ($n = 130$)	Female	128	98.5
BMI category[b] (WHO, 2004)	Underweight		30	4.3
	Healthy weight		399	56.8
	Overweight		175	24.9
	Obese		99	14.1
How did you hear about the 'Dairy Diary'?	Network at University of Pretoria		222	31.6
	From a dietitian/healthcare professional		150	21.3
	From a friend/colleague		109	15.5
	From a professional organisation		80	11.4
	From my company/ employer		55	7.8
	On the 'Dairy Gives You Go' website		49	7.0
	Facebook		38	5.4
How many times have you completed the 'Dairy Diary'?	Once		664	94.5
	Twice		27	3.8
	Three times		8	1.1
	More than three times		4	0.6
How are you completing this questionnaire?	On a smartphone		380	54.1
	On a desktop/laptop		323	45.9
	On a tablet		0	0.0
In general, how is your health?	Very healthy		478	68.0
	Somewhat healthy		216	30.7
	Not healthy		9	1.3
How often do you personally use nutrition- and health-related apps?	Daily (or almost daily)		155	22.1
	Weekly		126	17.9
	Monthly		72	10.2
	Hardly ever		350	49.8

[a]Self-report with online questionnaire. BMI (body mass index): self-reported weight (kg) divided by self-reported height (m) squared.
[b]Underweight: <18.5 kg/m^2; Healthy weight: 18.5–24.9 kg/m^2; Overweight: 25.0–29.9 kg/m^2; Obese: >30.0 kg/m^2.

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Table 4. Descriptive information of the nutrition professionals ($n = 130$).

Background characteristic		*n*	%[a]
Sex	Female	128	98.5
Do you recommend nutrition- and health-related apps to patients/clients?	Yes	78	60.0
What area do you mostly work in?	Private practice	60	46.2
	Government	23	17.7
	University/tertiary education	12	9.2
	I no longer practice as a dietitian	9	6.9
	Corporate/food industry	8	6.2
	Research	5	3.9
	Community setting	4	3.1
	Other[b]	9	6.9
Why do you recommend your patients/clients use health- and nutrition-related apps?[c]	For self-monitoring	65	50.0
	To increase awareness	53	40.8
	For motivation and extra support	47	36.2
	For goal setting	40	30.8
	As an information resource	39	30.0
	I do not recommend apps	26	20.0
	As a dietary assessment tool	24	15.5
	To reduce time during consultations	1	0.8
How do you know which health- and nutrition-related apps to recommend?[c]	From personal use of apps	86	66.2
	From recommendations from other dietitians and healthcare professionals	71	54.6
	From recommendations from my patients/clients	29	22.3
In your opinion, how do mobile apps compare to traditional (paper-based) methods for dietary assessment?	Mobile apps are better than traditional methods for dietary assessment	48	36.9
	Mobile apps are equivalent to traditional methods for dietary assessment	61	46.9
	Mobile apps are worse than traditional methods for dietary assessment	21	16.2

[a]Percentage of affirmative.
[b]Includes unemployed, food service management, medical/pharmaceutical representative, clinical, and non-profit organisations.
[c]Participants could select more than one option.

support' (36%). Respectively, 37% and 47% of nutrition professionals rated mobile apps as being 'better' or 'equivalent' to traditional methods for dietary assessment (Table 4).

Step 5: evaluation of the usability of the 'Dairy Diary' with uMARS: usability

For uMARS, the mean app objective quality score (3.9 ± 0.85), app subjective quality score (3.5 ± 0.77), app specific mean score (3.6 ± 0.94) and the additional question on e-portions (4.3 ± 0.78) met the minimum acceptability criteria of ≥3.0 (Mani *et al.*, 2015). For the subscales, layout (4.5 ± 1.0) and aesthetics (4.4 ± 0.80) scored highest, followed by information (4.3 ± 0.90) and functionality (4.0 ± 1.30). Engagement (3.0 ± 1.55) and willingness to pay for the app (2.27 ± 0.99) and customisation (2.05 ± 1.71) scored low (Table 5).

Discussion

South Africa leads the number of mobile app downloads in Africa (GSMA, 2019). Approximately 62% of South African consumers own a connected mobile device and 21% use the device to access healthcare information (Global Mobile Consumer Survey, 2017). Considering low dairy intakes in South Africa and the growing trend of smartphone usage, screening for dairy intake may increase awareness and consumption of dairy, thereby initiating, motivating and driving behavioural change to raise awareness of and improve low dairy intakes. Thus, we have described the development of the 'Dairy Diary', a web-based mobile app which includes an eight-item food list with portion size to calculate total daily dairy intake. Further to this, we evaluated the usability of the 'Dairy Diary' using uMARS (Stoyanov *et al.*, 2016).

Whilst many dietary screeners exist to assess for calcium intake in adults (Magarey *et al.*, 2014), few dairy intake screeners exist with a food only focus (as opposed to nutrient and/ or food focus). In 1995, the dairy questionnaire (DQ: Welten *et al.*, 1995) was developed as a traditional (paper-based) quantitative screener to estimate the calcium intake from dairy products in young adults (27–29 years). The DQ, also in a quantitative FFQ format, shows moderate to good reliability and is considered valid for the assessment of calcium intake from dairy products. Other dairy intake screeners by Angbratt and Möller (1999), Gans *et al.* (2006) and Goldbohm *et al.* (2011) also assessed both calcium and dairy intake.

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Table 5. The uMARS scale, sub-scales and items: mean and total score for the sample ($n = 703$)

Sub-scale	Item	Mean	SD
1. App mean objective quality score[a]		3.90	0.85
Engagement	1. Entertainment	3.23	1.38
	2. Interest	3.53	1.43
	3. Customisation	2.05	1.71
	4. Interactivity	2.46	1.69
	5. Target group	3.86	1.54
	Engagement Mean Score	3.03	1.55
Functionality	6. Performance	4.07	1.54
	7. Ease of use	4.13	1.36
	8. Navigation	3.79	1.45
	9. Gestural design	3.85	1.86
	Functionality Mean Score	3.96	1.33
Aesthetics	10. Layout	4.51	0.95
	11. Graphics	4.26	1.00
	12. Visual appeal	4.26	0.89
	Aesthetics Mean Score	4.35	0.82
Information	13. Quality of info	4.28	0.97
	14. Quantity of info	4.21	1.17
	15. Visual info	4.37	1.05
	16. Credibility of source	4.20	1.19
	Information Mean Score	4.27	0.90
2. App mean subjective quality score		3.49	0.77
Subjective quality	17. Recommend the app	3.71	1.24
	18. App use in one year	4.30	1.31
	19. Pay for app	2.27	0.99
	20. Overall star rating	3.69	0.72
3. App-specific mean score		3.56	0.94
App-specific	21. Awareness	3.82	1.05
	22. Knowledge	3.84	1.05
	23. Attitudes	3.46	1.11
	24. Intention to change	3.44	1.14
	25. Help seeking	3.47	1.18
	26. Behaviour change	3.31	1.19
Additional question on e-portions		4.27	0.78

[a]Mean of four objective sub-scales of 16 items: engagement (five items), functionality (four items), aesthetic (three items) and information (four items).

In Southern Africa, to the author's knowledge, dairy intake screeners do not exist. Thus, the 'Dairy Diary' is an original, novel and local technology-based dairy intake screener. With growing interest in technology-based dietary screening tools, evaluating the usability of dietary screeners is essential. Results from this study showed that the three mean scores in uMARS each met the minimum acceptable score of ≥3.0 (Mani *et al.*, 2015). The app objective quality mean score was the highest scoring domain, followed by the app specific mean score, and app subjective quality score. The functionality score was the highest and the engagement score was the lowest. This indicates the user's preference towards favouring input and participation when utilising the app. The same pattern of high functionality and low engagement has been reported in other studies using uMARS (LeBeau *et al.*, 2019; Davalbhakta *et al.*, 2020). LeBeau *et al.* (2019) evaluated 25 mobile apps used by occupational therapists, and Davalbhakta *et al.* (2020) evaluated 63 COVID-19 related apps. In both studies, high functionality and low engagement scores were reported.

Participants scored the layout of the 'Dairy Diary' the highest, followed by visual information. This suggests that participants value the aesthetic and visual appeal of the dietary screener, implying participants desire the opportunity to adapt and personalise the dietary screener, an observation which may be particularly relevant to the nutrition professional. In this study, participants scored high on the subscales of information, quality of information, quantity of information and credibility of the source. To the contrary, when evaluating nutrition-related apps in Brazil, Braz and Lopes (2018) found that mobile apps were not based on reliable sources of information. This was supported by Byambasuren *et al.* (2019) where 16% of Australian general practitioners reported a lack of trustworthy sources as a barrier to prescribing apps in practice.

Customisation and willingness to pay for the appscored lowest, suggesting that users may be less inclined to use the app if payment was requested. Accordingly, future considerations to enhance user participation may include more customisation options for the 'Dairy Diary' to tailor to the user's preferences. Future research may also evaluate the usability of the 'Dairy Diary' in different age and gender groups. In addition, planners of public health initiatives may benefit from the outcome of the 'Dairy Diary' to screen for low dairy intakes among the general public. It may also be valuable to evaluate the usability of a traditional (pen and paper) version of the 'Dairy Diary' in these different populations.

For nutrition professionals, the 'Dairy Diary' may be a simple and practical tool to screen for low dairy intakes, driving dairy-related nutrition education. Such a tool may serve as a trigger into the nutrition care process for more comprehensive dietary assessment. Including apps into dietetic practice could enhance the efficiency and quality of nutrition care and counselling, supporting that nutrition professionals play a leading role in the development of such dietary screeners (Chen *et al.*, 2018). For this reason, the study population included a sub-group of nutrition professionals in South Africa.

To the authors' knowledge, nutrition- and health-related mobile app use among South African nutrition professionals is unknown. In the present study, 60% of nutrition professionals recommend app usage to patients, with two-thirds basing their recommendation from personal use of the apps. Higher proportions (79%) of mobile app usage have been reported in American dietitians (Sharman and Ashbury, 2015), as well as in the Clinician Apps Survey (85%: Karduck and Chapman-Novakofski, 2018). Sauceda *et al.* (2016) reported 83% of healthcare providers recommend nutrition- or health-related apps to patients. Lower mobile app recommendations have been reported in an international survey of healthcare professionals from 73 countries (46%: Vasiloglou *et al.*, 2020). Canadian dietitians (57%: Lieffers *et al.*, 2014), Irish dietitians (42%: Timon, 2018) and sports dietitians in Australia, Canada, New Zealand, United States and the United Kingdom (32%: Jospe *et al.*, 2015) likewise have shown lower usage.

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In South Africa, mobile data costs are among the highest in the world (Moyo and Munoriyarwa, 2021), despite 83% smartphone penetration in 2018 (nearly double that of 2016: ICASA, 2019). At the same time, internet and fibre-to-the-home/building internet subscriptions increased by 42% and 279%, respectively (ICASA, 2019). High mobile data costs may potentially explain lower app recommendation by nutrition professionals in South Africa compared to other countries, despite increased internet access.

Jospe *et al.* (2015) found that dietitians describe apps as 'better' (47%) or 'equivalent' (41%) to traditional dietary assessment methods. In our study, results were similar with 37% and 47% of dietitians reporting that mobile apps are 'better' or 'equivalent to' traditional methods for dietary assessment, respectively. The generalisability of this study may be considered limited in that three-quarters of consumers and almost all of the nutrition professionals were female. Traditionally, the nutrition profession is known to be mostly female, as supported by the Association of Dietetics in South Africa (ADSA) membership profile with 97.1% being female (ADSA, 2022). The evaluation of the usability may also be different in lower LSM groups. Thus, it may be pertinent to evaluate the usability of the 'Dairy Diary' in other populations.

In conclusion, as evaluated by uMARS, the 'Dairy Diary' is a technology-based, user-friendly dairy intake screener. For a dietary screening tool to be of value, its performance needs to be assessed in terms of reliability and validity. If reliable and valid, such a screener may contribute to the cost-effective assessment of dairy intake. Future validation studies of the 'Dairy Diary' are recommended.

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