

Adaptation of the RenalSmart® web-based application for the dietary management of patients with diabetic nephropathy

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Abstract

Objectives: The aim of this study was to develop and test a web-based application for the dietary management of patients with diabetic nephropathy.

Design: Observational descriptive study.

Settings and subjects: RenalSmart® is a web-based application used to assist dietitians in clinical practice, from tertiary to primary care, to manage patients with chronic renal failure. The application was adapted and enhanced to include functions for the nutritional assessment of a patient with diabetic nephropathy, the formulation of a dietary prescription and the development of a meal plan and sample menu. It includes a graphical display of anthropometric and biochemical measurements. Quality assurance testing was undertaken throughout the development process by the project team in a pilot study involving generalist dietitians and dietitians who specialise in diabetic and renal nutrition. Non-random purposive sampling, including snowball sampling, was used to recruit them.

Outcome measures: The application was finally tested for accuracy and acceptability by registered dietitians in South Africa.

Results: Thirty-seven dietitians completed the final testing of the application. The mean age of the respondents was 33 years. Thirty-five per cent resided in the Western Cape. The overall acceptability of the application was rated as good to excellent by 81% of respondents. There was a significant difference between dietitians who usually consulted renal patients, compared to those who did not, in their rating of the accuracy of the data-saving function (p -value = 0.02) and the fluid requirements (p -value = 0.03). In this regard, the former group of dietitians was dissatisfied with these functions.

Conclusion: The web-based application developed in this study was rated as accurate and acceptable by the majority of respondents. Identified problem areas were addressed in the final version.

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Introduction

The leading cause of chronic kidney disease (CKD) in developed countries is diabetes, and it is rapidly becoming the leading cause in developing countries like South Africa as well as a result of the worldwide increase in type 2 diabetes and obesity.^{1,2}

Metabolic derangements, like hyperglycaemia, were shown to be a major determinant of the progression of diabetic nephropathy in the Diabetes Control and Complications Trial.³ It has also been reported that intensive glycaemic control retards the rate at which both microalbuminuria and overt nephropathy develops in patients with type 1 diabetes.⁴ Some studies have shown that dietary protein restriction is beneficial in postponing stage V CKD and death, especially in type 1 diabetes.^{1,5,6} Two systematic reviews^{7,8} on the renal effects of low-protein diets in diabetic nephropathy

showed that low-protein diets did not have a significant effect on the improvement of kidney function, as measured by glomerular filtration rate in patients with type 1 and type 2 diabetes. However, there was a significant decrease in proteinuria or albuminuria, as well as a significant decrease in haemoglobin A_{1c}.⁸

According to the National Kidney Foundation Kidney Disease Outcome Quality Initiative™ (NKF KDOQI™) 2007,¹ the dietary protein intake for diabetic kidney disease between stages I-IV should be the same as the recommended dietary allowance of 0.8 g/kg per day. The dietary protein requirement for the patient with diabetes with CKD should be based on ideal body weight because of the high prevalence of obesity in this patient population.¹ Lifestyle adaptations and some nutrition-related advice are recommended during stage I and II of CKD, while moderate changes in dietary protein intake can

Table 1: Dietary recommendations for adults with diabetic nephropathy^{1,13,16-20}

Requirements	Pre-dialysis	Haemodialysis	Peritoneal dialysis
Protein g/kg/day	NKF KDOQI™: 0.6-0.8	NKF KDOQI™: 1.2	NKF KDOQI™: 1.2-1.3
High biological value protein (%)	NKF KDOQI™: 50 (at least)	NKF KDOQI™: 50 (at least)	NKF KDOQI™: 50 (at least)
Energy (per day)	H-B kcal or 30-35 kcal/kg	H-B kcal or 30-35 kcal/kg	H-B kcal or 30-35 kcal/kg
Carbohydrates (% TE)	50-60	50-60	50-60
Fat (% TE)	≤ 30	≤ 30	≤ 30
Saturated fatty acids (% TE)	≤ 10	≤ 10	≤ 10
Polyunsaturated fatty acids (% TE)	6-8	6-8	6-8
Monounsaturated fatty acids (% TE)	≤ 15	≤ 15	≤ 15
Cholesterol (mg/day)	< 200	< 200	< 200
Fibre (g/day)	20-30	20-30	20-30
Fluid (ml/day)	Output + (500-750)	1 000- 2 000	1 000-3 000
Sodium (mg/day)	< 2 300	2 000-4 000	2 000-4 000
Potassium (mg/day)	2 000-3 000 (restrict if raised)	2 000-3 000	2 000-4 000
Calcium (mg/day)	< 2 000-2 500 (including binder)	< 2 000-2 500 (including binder)	< 2 000-2 500 (including binder)
Phosphorous (mg/day)	800-1 000	800-1 000	800-1 000
Iron (mg/day)	10-18 (individualise supplementation)	10-18 (individualise supplementation)	10-18 (individualise supplementation)
Zinc (mg/day)	12-15 (male) 10-12 (female)	12-15 (male) 10-12 (female)	12-15 (male) 10-12 (female)
Selenium (µg/day)	55	55	55

H-B: Harris Benedict Equation for determining basal energy expenditure, NKF KDOQI™: National Kidney Foundation Kidney Disease Outcome Quality Initiative™, TE: total energy

have a positive effect on the excretion of albumin in the urine during those stages.^{9,10} During stage III CKD and onwards, it is important to monitor the patient's nutritional status and dietary compliance, while decreasing dietary protein intake to 0.8-1g/kg per day. A dietary protein intake of 0.6-0.8 g/kg per day is recommended from stage IV CKD.¹⁰ However, with such a low protein intake, it is difficult to achieve optimal energy intake as an insufficient energy intake can be detrimental and result in protein catabolism, a negative nitrogen balance and weight loss.¹¹

Dietary intervention for diabetic nephropathy can be complicated. A requirement is that many different aspects beyond glycaemic control need to be addressed,¹² since management involves multiple nutrients, including protein, carbohydrate, fat, sodium, potassium and phosphate.¹³ Primary nutritional goals include matching dietary intake and the medical management of diabetic kidney disease, maintaining and achieving glycaemic control and a healthy body weight and managing or decreasing nutrient imbalances.¹⁴ Therefore, nutritional management of these patients should be individualised.¹ Table 1 provides a summary of the dietary recommendations for adults with diabetic nephropathy, covering the macronutrient, fluid and mineral requirements based on specific treatment for renal failure.^{1,13,15-18}

Since the launch of the RenalSmart® application in 2008, a web-based tool developed for registered dietitians to manage patients with kidney disease, informal feedback from registered users included a recommendation of inclusion of a tool that could be used for the dietary management of the patient with diabetes and kidney disease, because of the complexity of the disease.

Method

Objectives

The study objectives were to:

- Determine which diabetes exchange lists should be used to develop the RenalSmart® database.
- Compile guidelines for the dietary requirements of patients with diabetic nephropathy, using the latest evidence-based guidelines.
- Adapt the existing RenalSmart® web-based application to compile a dietary prescription and meal plan for patients with diabetic nephropathy.
- Test the accuracy of the application.
- Test user acceptability of the application.

Study type

This was an observational descriptive study.

Target population

The sampling frame comprised dietitians who were registered with Association for Dietetics in South Africa (ADSA), dietitians employed by universities offering a dietetics undergraduate programme and those employed by government and private hospitals with a nutrition department in South Africa. The study population consisted of generalist and specialist dietitians. This decision was taken to cater for all potential users of the programme and to prevent the study from being conducted using a small, biased sample that was not representative of registered dietitians from different ethnic and cultural backgrounds.

Sampling

Non-random, purposive sampling was used, including snowball sampling to obtain more e-mail contacts.

Inclusion and exclusion criteria

The study sample included a combination of registered, generalist dietitians and dietitians specialising in diabetic or renal nutrition. Participants had to be proficient in English and to be computer literate, with an available e-mail address. Dietitians who refused to participate, and those who did not have access to e-mail and the Internet, were excluded.

Development process of the RenalSmart® diabetic nephropathy application

The development of the database for the RenalSmart® diabetic nephropathy application involved revising, restructuring and developing a combination of multiple functions, as well as formulating an appropriate dietary prescription. It now displays the same format, with similar categories, to that of the previous RenalSmart® application, but with specific adaptations that are appropriate to diabetes.⁸ The backbone of the adapted RenalSmart®

application consists of interactive mathematical functions and a sound database, scientifically based and validated by various experts in the field. These functions allow the registered dietitian to modify and update data over time as new developments in the management of patients with diabetic nephropathy become available. As the RenalSmart® application is a tool that was developed for sole use by registered dietitians, access to the programme was allowed after approval by the system administrators.

Project team

The project team consisted of the investigator, experienced in renal nutrition, two co-developers, a web-designer, two endocrinologists and three consulting dietitians who specialise in the management of diabetes (two from the government sector and one from the private sector).

Phases of the study

Adaptation of the application was divided into six phases (Figure 1), starting with modifications to the current RenalSmart® application using requirements and exchange lists that are specific to diabetes and renal disease. The end product was the release of the application.

Phase 1

During Phase 1, information on the exchange lists currently used by dietitians was investigated and feedback was obtained through telephonic or e-mail communication. This was carried out at provincial level, in consultation with the ADSA, dietetics departments at various universities, the Nutrition Information Centre of Stellenbosch University, healthcare facilities and hospitals in South Africa, as well as known specialists in the field of diabetes. Information was also obtained on the diabetic nephropathy dietary recommendations used to formulate a dietary prescription. Extensive literature searches were carried out to assess current dietary recommendations, based on the latest available evidence on diabetic nephropathy.^{1,13,21}

Phase 2

In Phase 2, the RenalSmart® web-based application was adapted for diabetic nephropathy (Figure 2). The existing database was modified and created anew by the investigator using the “Food options” and “Consultation” functions, as follows:

- Food composition data were incorporated, based on the American Dietetics Associations (ADA) diabetes exchange lists.
- The dietary recommendations for diabetic nephropathy, identified in the first phase, were incorporated.
- Templates were designed to calculate a dietary prescription, and exchanges for patients with diabetic nephropathy treated conservatively by haemodialysis or peritoneal dialysis.
- A list of biochemical measurements and target values was compiled and abnormal values interpreted.
- A medication list was assembled to include diabetes-specific medication, its mechanism of action, nutritional side-effects and dietary implications based on these side-effects.

Phase 3

Phase 3 focused on quality assurance procedures by the project team (Figure 3) to test the accuracy of the application. During this phase,

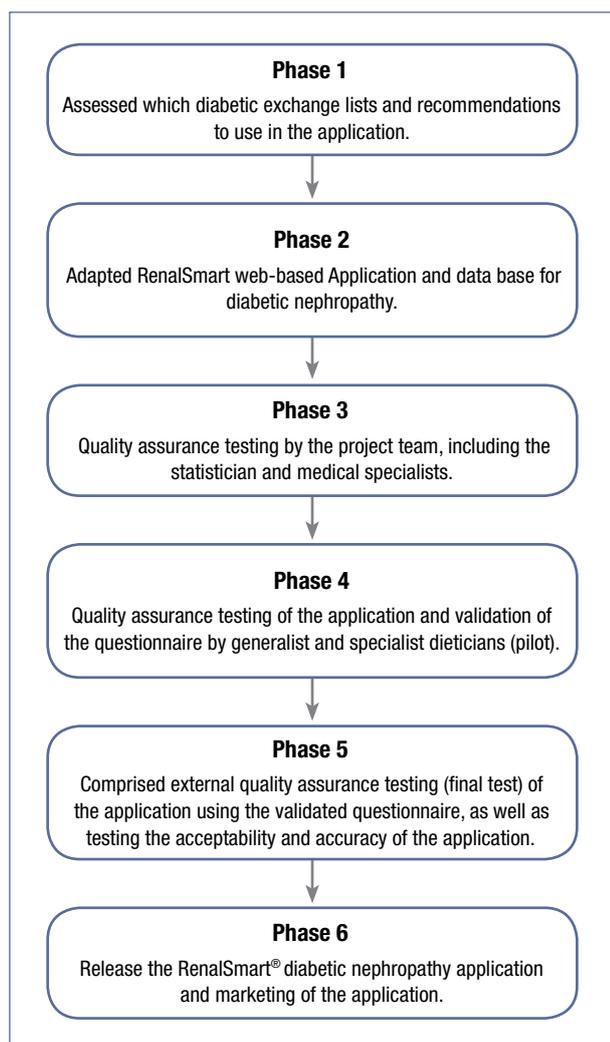


Figure 1: Flow diagram of the processes followed to adapt the RenalSmart® application for diabetic nephropathy

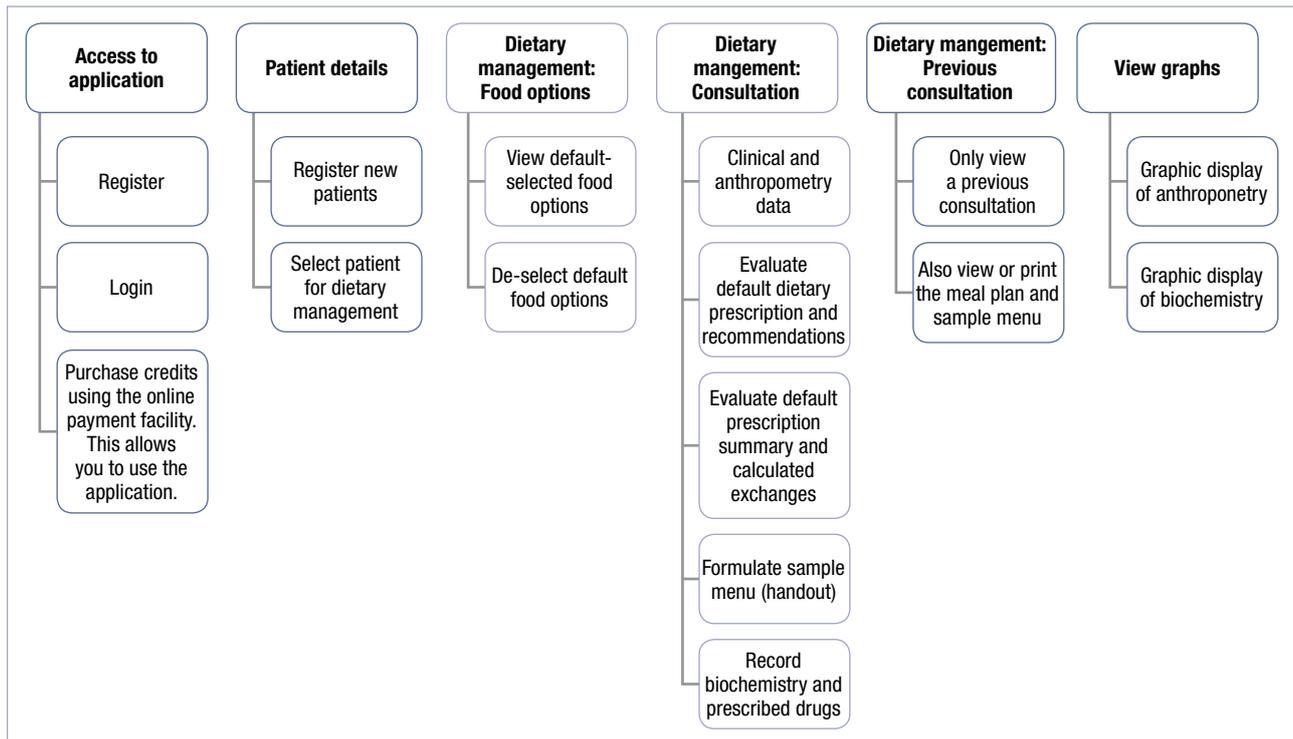


Figure 2: Phase 2: Adapting the RenalSmart® web-based application for diabetic nephropathy

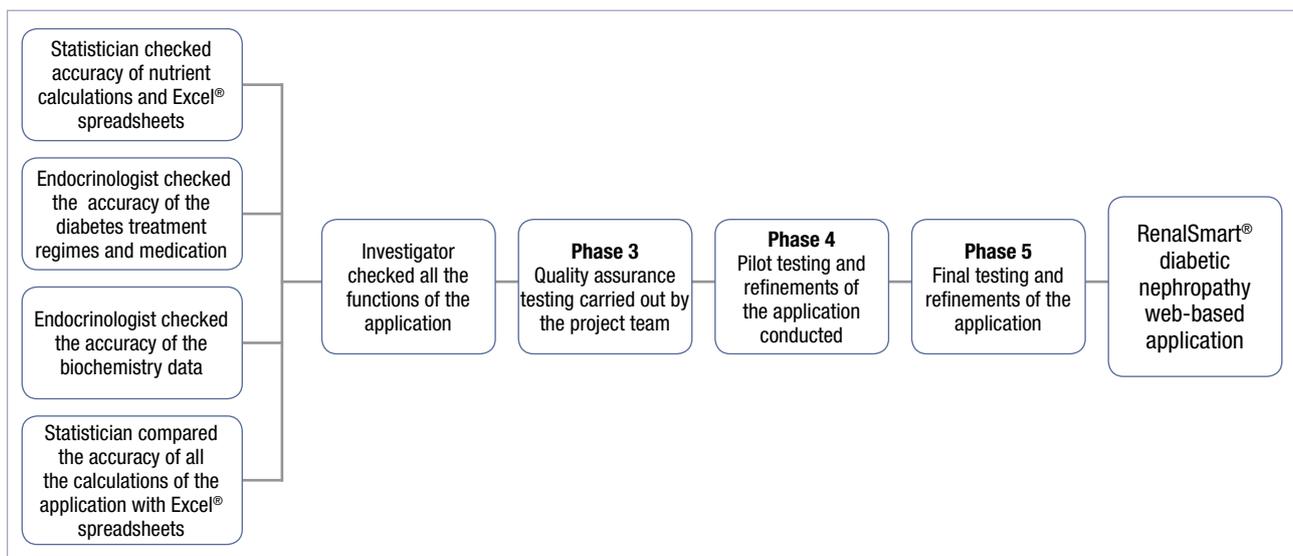


Figure 3: Quality assurance testing stages of the application

the application, available on a test server, was fully operational to determine whether or not it was fully functional. The formulae used in the application were tested for accuracy by a statistician at two different points of the study. First, calculations and equations carried out on Excel® spreadsheets were tested for accuracy, before the data were handed over to the web designer. The second test took place after the web designer used this data for the development of the application by comparing it to the results of the first test to see if the calculations were similar. Information on the biochemistry and medication was checked by two diabetic medical specialists. A nephrologist was involved in the testing of the renal-specific data of the original application. The data were adopted without any further modifications.

Phase 4

During Phase 4, the structured questionnaire to be used in Phase 5 was finalised and tested for face validity (Figure 3). Twelve people were invited to participate in the pilot study. These comprised generalist dietitians and dietitians who specialised in diabetic or renal nutrition who were registered ADSA members, and dietitians from different provinces working in the government and private sectors from different ethnic and cultural backgrounds. The e-mail system was used as a communication medium since it is free of charge. The questionnaire used to test the application could also be delivered and returned much faster to the Stellenbosch University survey website after completion.²²⁻²⁴ The e-mail provided the link to

the RenalSmart® application's test server that allowed dietitians to test the application using personalised login details. Internet access was required to test the adapted RenalSmart® application, as it is a web-based programme. The questionnaire consisted of both closed- and open-ended questions. A four-point Likert scale was applied to some of the questions, e.g. "strongly agree", "agree", "disagree" and "strongly disagree". No neutral or undecided choices were available.²⁵

Phase 5

Phase 5 was the final test of the application (external quality assurance) using the same study population described in phase 4 and the same questionnaire that was validated in phase 4 (Figure 3). Demographic information obtained from the dietitians who participated in the survey included age, the province in which they worked or practised, whether or not they were government or private practice based, worked with diabetic and/or renal patients, whether or not they had practical experience using RenalSmart®, their type of Internet connection, i.e. broadband or dial-up, and self-rating of their computer literacy based on a four-point Likert scale ranging from "very good" to "very poor". To improve the response rate, seven reminders were sent to participants who had not yet completed the survey, but who had indicated an interest in participating in it, to improve the response rate. Adjustments and further refinements of the application were then made after the final testing.

Phase 6

Phase 6 was the subsequent release and marketing of the RenalSmart® diabetic nephropathy application (not part of the study).

Statistical methods

MS Excel® was used to capture the data and Statistica® version 10²⁶ to analyse the data. Descriptive statistics were utilised to describe the variables. The distribution of the variables was presented with histograms and/or frequency tables. Means were used as the measure of central location for ordinal and continuous responses, and standard deviations as indicators of spread. A p-value of < 0.05 was indicative of statistical significance in hypothesis testing.

Ethical and legal aspects

The protocol for the proposed study was submitted to, and subsequently approved by, the Health Research Ethics Committee, Faculty of Health Sciences, Stellenbosch University (N10/04/130). Participation was voluntary. All the information was handled confidentially using a built-in coding system. Responses were captured independently by an electronic Stellenbosch University survey database.

Results

Phase 1: Exchange lists and recommendations

The food composition data, comprising the ADA diabetes exchange lists and the dietary recommendations for diabetic nephropathy, were based on the NKF KDOQI® 20071 clinical practice recommendations. (These recommendations were used since they are based on a systemic review of the literature).

Phase 2: System and content design of the application

Development of the database and functions of the application described above was carried out using the WordPress engine as the RenalSmart® homepage²⁷ is a standard WordPress blog. Access to the homepage was unrestricted, where news and information of interest to the dietetic profession are posted. The application is hosted on a Stellenbosch University server and the RenalSmart® diabetic application is available on the existing RenalSmart® blog.²⁷

Phase 3: Internal quality assurance testing

No corrections were required to the formulae used. The endocrinologists provided input on the appropriate diabetes treatment regimes, prescribed available drugs in South Africa and biochemical targets used in diabetes management.

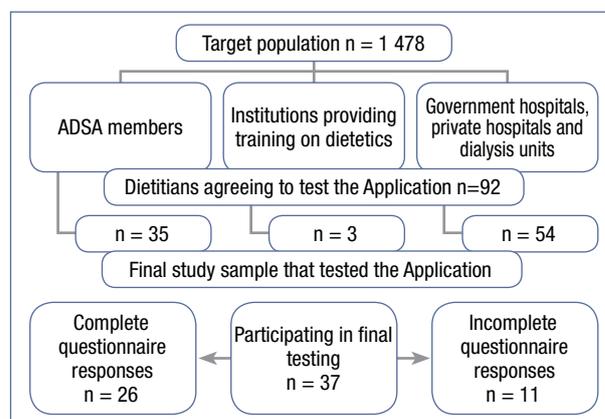
Phase 4: Pilot study

Only four of the 12 participants who initially agreed to participate in the pilot study completed the survey. However, this smaller sample size was accepted since the main study population already consisted of a relatively small sample of healthcare professionals. Feedback included suggestions on improving and displaying a more logical sequence for using the application, as well as a more detailed explanation on the individual functions. Changes made to the application included a detailed flow diagram of the steps to follow and more descriptive footnotes on every screen function.

Phase 5: External quality assurance testing

Description of the sample

Of the 92 dietitians who initially agreed to participate in the external testing, 37 female respondents completed the voluntary testing of the application (Figure 4). The mean age of the respondents was 33 years (Table II) and they were mostly from the Western Cape (35%). Most of the respondents (57%) were employed by the government sector. Ninety-seven per cent and 81% of dietitians consulted patients with diabetes mellitus and renal disease, respectively. Only 22% had previous experience with the RenalSmart® Application, the majority (8%) of whom came from the Western Cape. Forty-six per cent used asymmetric digital subscriber line (ADSL) technology and 35% broadband connection for Internet access to test the application, compared to 14% who used a dial-up Internet



ADSA: Association for Dietetics in South Africa

Figure 4: Recruitment process of the final testing phase

connection. The respondents' computer literacy rating showed that 81% rated themselves as "very good", and 19% as "good". There were no "poor" responses.

Table II: Profile of the participants

Description of sample (n = 37)	Results, n (%)	
Mean age (years)	33 (SD 7.77)	
Work in the government sector	21 (57)	
Work in the private sector	16 (43)	
Consult patients with diabetes	36 (97)	
Consult patients with renal failure	30 (81)	
Previous experience with RenalSmart®	8 (22)	
Province	Results, n (%)	Experience with RenalSmart® (%)
Western Cape	13 (35.1)	8
Eastern Cape	9 (24.3)	5.4
Gauteng	7 (18.9)	5.4
KwaZulu-Natal	5 (13.5)	2.7
Free State	1 (2.7)	0
Limpopo	1 (2.7)	0

SD: standard deviation

Testing accuracy of the application

The accuracy rating by dietitians was very high (75-95% of respondents) (Table III) for the various functions, compared to 6-24% of dietitians who rated the individual functions as inaccurate. (Twenty-four per cent of dietitians were dissatisfied with the data-saving function). There was no significant difference (p -value > 0.05) in the mean age of respondents and their responses to testing the accuracy of the application. The exception was the accuracy in the transfer of the calculated prescription to the prescription summary, and the printing function for the meal plan and sample menu handout, where respondents who experienced problems with accurate transfer of information and printing of the meal plan were significantly older (p -value = 0.04). When testing the accuracy of the application, there was no significant difference (p -value > 0.05) between dietitians who usually consulted patients with diabetes (compared to those who did not), dietitians who had used the RenalSmart® application before (compared to those who had not used it previously), and dietitians with "good" or "very good" self-rated computer literacy skills. There was a significant difference between dietitians who usually consulted renal patients (compared to those who did not), and the accuracy of the data-saving function of the application and fluid requirements. These dietitians were dissatisfied with the data-saving function of the application (p -value = 0.02) and the recommended fluid requirements (p -value = 0.03).

Testing acceptability of the application

The majority of respondents (81%) rated the acceptability of the RenalSmart® application as good to excellent (Figure 5). The demographic profile of the respondents (Table IV) did not have a significant influence (p -value > 0.05) on the results. The application functions that some of the respondents found difficult to understand included the menu planning and prescription summary functions

Table III: Accuracy rating of the application per question (n = 37)

Questions	Responses	
	Yes, n (%)	No, n (%)
Was the calculated prescription transferred accurately to the summary of the calculated exchanges/prescription?	29 (85)	5 (14)
Did the printing function work to print the meal plan and sample menu handout?	25 (78)	7 (22)
Were the clinical data saved successfully?*	30 (81)	7 (19)
Were the fluid requirements determined accurately from the urine volume?*	33 (94)	2 (6)
Was the frame size transferred correctly from the patient data sheet to the clinical data sheet?*	32 (86)	5 (14)
Was the height transferred correctly from the patient data file to the clinical data sheet?*	34 (92)	3 (8)
Do you agree with the suggested diabetes medication regimes?*	31 (84)	6 (16)
Were you able to change the prescription summary manually, if needed?*	30 (86)	5 (14)
Was the dietary prescription saved accurately?*	29 (83)	6 (17)
Did your final menu plan save successfully?*	26 (76)	8 (24)
Were you able to make changes, if needed, to the number of exchanges?*	28 (82)	6 (18)
Did the changes you made in the number of exchanges result in a corresponding change in the suggested prescription summary after the "Calculate" function was used?*	29 (85)	5 (15)
Do you agree with the suggested biochemical investigations that are specific to diabetes?*	26 (81)	6 (19)
Do you agree with the prescribed oral medication and insulin drugs for diabetes?*	27 (84)	5 (16)

*. Respondents who usually consulted patients with renal disease did not agree with the accuracy of the data-saving function of the application and the fluid requirements.

**No significant difference (p -value > 0.05) was found in testing the accuracy of the application with regard to respondents who usually consulted patients with diabetes (compared to those who did not), dietitians who had used the RenalSmart® application before (compared to those who had not used it previously), and dietitians with "good" or "very good" self-rated computer literacy skills.

(Table IV). There was no significant difference in the rating of older, compared to younger, dietitians (p -value > 0.05), and no significant difference (p -value > 0.05) between dietitians who usually consulted patients with diabetes or renal patients (compared to those who did not), dietitians who had used the RenalSmart® application before (compared to those who had not), and dietitians with "good", rather than "very good" self-rated computer literacy skills. Concern was

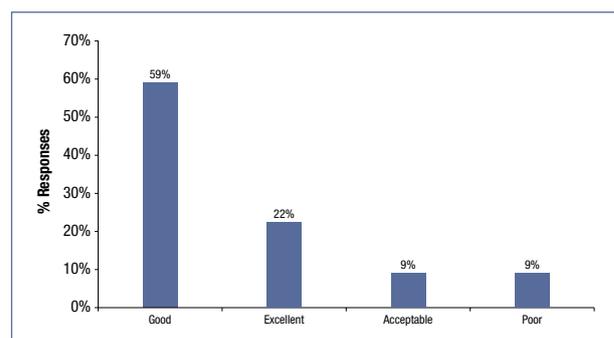


Figure 5: Rating of the acceptability of the application

Table IV: Acceptability rating of the application per question (n = 37)

Questions	Number*	Responses			
		Strongly agree n (%)	Agree, n (%)	Disagree, n (%)	Strongly disagree, n (%)
The section on clinical data was easy to complete.**	37	12 (32)	21 (57)	3 (8)	1 (3)
The instructions were clear on the weight that must be used to calculate the dietary prescription.**	37	8 (22)	28 (76)	0 (0)	1 (3)
The section on "Dietary prescription" was easy to follow.**	35	6 (18)	21 (60)	7 (20)	1 (3)
The section on "Prescription summary" was easy to follow.	34	5 (15)	25 (74)	1 (3)	3 (9)
It was easy to use the "Next default" function to match suggested prescriptions to the dietary prescription.**	34	4 (12)	22 (65)	6 (18)	2 (6)
The section on "Menu planning" was easy to complete.**	32	6 (19)	16 (50)	6 (19)	4 (13)
The meal distribution, including snacks, was correctly distributed.**	32	7 (22)	21 (66)	3 (9)	1 (3)
It was easy to add food items to the menu.**	32	5 (16)	22 (69)	1 (3)	4 (13)
It was easy to delete food items from the menu.**	32	7 (22)	21 (66)	1 (3)	3 (9)
It was easy to customise or de-select the listed default food options.**	32	6 (19)	19 (59)	5 (16)	2 (6)

* The total number of responses was 37, but some questions were not completed by every respondent.

** No significant difference was found in the rating of older, compared to younger, dietitians (p-value > 0.05), and no significant difference (p-value > 0.05) was established between dietitians who usually consulted patients with diabetes or renal patients (compared to those who did not), dietitians who had used the RenalSmart® application before (compared to those who had not used it previously), and dietitians with "good" or "very good" self-rated computer literacy skills.

raised by six respondents on the use of non-renal diabetic exchange lists for patients with diabetic nephropathy, and also with regard to the dietary prescription which did not indicate the sodium, potassium and phosphate requirements that are often restricted in CKD.^{1,13}

Adaptations to the application based on feedback from the final testing

The following adaptations were made to improve the user-friendliness of the application:

- A "User guide" function appears on every screen and includes a flow diagram of the steps to follow and a short summary of how the application functions.
- Additional footnotes were included with every function, indicating the sequence of steps to be followed with every function. In addition, when using the "Help" function, a detailed manual instruction guide of the screen function appears.
- Data are now automatically saved when changing the application's screen options.
- The fluid prescription was left unchanged to allow for individualised prescriptions.

Discussion

The logical stepwise design of the application allows for a quick and easy approach when using the application for the dietary management of diabetic nephropathy.

The study objectives were addressed as follows:

- The dietary requirements of patients with diabetic nephropathy were based on the latest international recommendations,^{1,13,21} including limited evidence-based research, and when sufficient evidence was lacking, recommendations were based on expert opinion.
- In the absence of South African-based diabetes exchange lists, the ADA diabetic exchange lists^{28,29} were used as an essential

part of the recommended "Food options" and "Meal planning" functions.⁵ Exchanges were formulated to meet various prescriptions.

- Appropriate dietary prescription and meal plan functions were developed to standardise dietary recommendations and implementation methods.³⁰
- The accuracy of the application was tested.
- The acceptability of the application was established during the final testing phase.

The respondents were all women (the eldest was aged 51 years), since the South African dietetics profession is a female-dominated profession (confirmed by the Health Professions Council of South Africa Register of Professional Board for Dietetics 2009, 3 November). Respondents were employed in the government sector mostly. In addition, the contact details of dietitians working in the government sector were more freely available, possibly because of the snowball sampling method used. There were respondents from six of the nine provinces. This is indicative of the diversity of cultural backgrounds of the dietitians who participated in the study. As most respondents were from the Western Cape, an element of selection bias is implied, since contact details were more freely available from this province as a result of snowball sampling. These participants were also more familiar with the application, since all three training institutions in the Western Cape train undergraduate students on the RenalSmart® application, while the University of Pretoria is the only university in the Gauteng province that trains its undergraduate students to use the application. Even though their self-rated computer literacy was "very good", the majority of the respondents had no experience using the RenalSmart® application. This could, in part, explain why they were unfamiliar with the functions of the application, and also account for the negative feedback reported by some respondents with regard to its user-friendliness.

The survey response rate was low (37 of the 1 478 contacted), which affected the interpretation of the accuracy and acceptability of the application,³¹ yet more than double the number of dietitians tested the adapted version, compared to those who tested the original RenalSmart® application (17 respondents) (Herselman MG 2011, 1 August). Generally, electronic surveys have a low response rate, despite seven electronic reminders having been sent out in the course of the survey. This phenomenon is because respondents are concerned about computer viruses and delete e-mails that are unsolicited or received from an unknown sender.³² Other reasons for the poor response may have included the fact that not all dietitians had an e-mail address or Internet access (a requirement for inclusion); the e-mail contact details of some of the registered dietitians could not be obtained; some dietitians did not work in therapeutic nutrition; and those who were unfamiliar with the application would possibly have taken a long time to test and complete the questionnaire; respondents who used a dial-up Internet connection to test the application could have experienced a slow or poor Internet connection, resulting in dropout; a high volume of web traffic was experienced during peak times of the day;³² while different types of browsers and operating platforms, as well as Internet connection speed, could have affected the display and the ease of using the application and questionnaire. In turn, this may have influenced people's decision on whether or not to participate.³³ The development and testing of a similar web-based dietary management programme (not for patients with CKD), was previously reported by dietitians in Malaysia.³⁴ In this study, the final product was tested by 10 dietitians.

The accuracy of the application was consistently rated positively by more than 75% of the respondents. No significant difference was found between the older and younger participants with regard to their responses to any of the questionnaire items. The exception was the transfer of the calculated prescription and the printing function for the meal plan and sample menu handout. Members of the older group experienced problems with these functions. This could be explained by the possibility that older respondents are less familiar with the application's functions and less computer literate using web-based tools, than their younger counterparts.³⁵⁻³⁷ Younger adults, exposed to technology from an earlier age, have more efficient computer skills than older adults, especially when using new technologies.³⁵ More training and practise should be considered in order to overcome limitations of technological skills in older adults.³⁵⁻³⁷ Nevertheless, contact details are available on the application and the user can seek help.

There was a significant difference between the rating of the accuracy of the data-saving function of the application and the fluid requirements by dietitians who usually consulted renal patients and those who did not. The reported difference in fluid requirements could be explained by the fact that these dietitians are more familiar with, and more critical of, the accuracy of the dietary and fluid prescriptions for individual patients. It appeared that it was not clear if the fluid requirements included the fluid content of the diet. This was addressed in the instruction manual. It was also not clear why the recommended fluid allowance for all the treatment options were output plus insensible losses: a

recommendation for the conservative management of patients.¹³ A standard minimum fluid allowance to maintain body fluid balance was used to calculate the fluid requirements for all of the treatment modalities, since individual fluid requirements vary from day to day. Fluid requirements can be modified, based on clinical judgement.^{28,38} The reason for the difference between the rating of the accuracy of the data-saving function by dietitians who usually consulted renal patients and those who did not is unclear and is open to speculation. Following adaptations to the application, all data will now be saved automatically on the server. This information will be available under the "User guide" section and in the application manual.

The majority of respondents (26 of the 37) were satisfied with the functions of the application. Examples of distinct differences in the reported acceptability rating of the application include: "It is very user-friendly, complete with clear instructions", and: "It is not user-friendly, or easy to follow". It is possible that these differences could be attributed to respondents' computer literacy levels with web-based programmes. Certain respondents were more experienced with RenalSmart®, or consulted more patients with diabetes with CKD than others. Others may have neither fully read nor understood the instructions. To overcome these problems, a summary "User guide" section, that highlights the most important points of the application, as well as the steps to follow, was included in the "Help" function as a picture display with instruction manual, and is now available on every screen.

However, use of the renal exchange lists was not possible because many of the food options that were listed in the renal exchange lists are unsuitable for patients with diabetes, e.g. portion sizes are based on the protein content of food options in renal exchange lists, compared to portion sizes based on the carbohydrate content of the food options in diabetes exchange lists. Also, diabetic nephropathy is usually a diabetes-related complication which develops after many years.²⁸ This implies that these patients will already be familiar with the diabetes exchange lists, having been exposed to them for some time, hence requiring only minor modification because of dietary restrictions imposed as a result of renal failure.^{13,28} To overcome the problem of diabetes exchange lists that do not include information on the mineral content of foods, additional educational handouts will be made available on the application in respect of such dietary restrictions. However, this was beyond the scope of this study and will be addressed when making future refinements to the application. Dietitians are known to use a variety of exchange lists to manage diabetic nephropathy. This could remain a problem because of a lack of alternative South African diabetes exchange lists.

Currently, the RenalSmart® programme is the only one that is available in South Africa for the dietary management of diabetic nephropathy. Even though other web-based programmes are available internationally, like DietPal,³⁴ its development and testing for this target group has not been published in a scientific journal. Extensive Internet and literature searches revealed that most of the web-based programmes that are available internationally provide only educational patient self-management tools that do not necessarily involve face-to-face contact with the healthcare professional, a unique feature that has been catered for in the RenalSmart® application.

Limitations include the application's handouts, currently available in English only, and the fact that they are not suitable for illiterate patients. Lastly, the food options from the ADA exchange lists were used since no South African-specific diabetes exchange lists are available.^{23,26} This is a major limitation of the programme, especially in the dietary management of diabetes, as the food options listed in these exchange lists are not culturally sensitive in the local context. Future developments in the treatment of diabetes and diabetic kidney disease should include the development of South African-based diabetes exchange lists. The small number of dietitians who participated in the testing of the programme was a major limitation, so the results of phase 5 cannot not be generalised to the South African dietetic community at large. Participants were informed of a financial incentive concerning the costs incurred with Internet use. Even so, this did not have an impact on the response rate. The low response rate is in agreement with that of other surveys which have been conducted via e-mail, where the response rate was also reported to be poor.³³ To overcome this limitation, the programme made provision for regular feedback from users about problems experienced with either the content or the performance of the programme on its blog.

In conclusion, the RenalSmart® web-based application for the patient with diabetes with CKD was developed using the latest evidence-based literature on the dietary management of diabetic nephropathy. Several quality assurance checks were built into the developing process to ensure accurate performance of the programme. Although it was rated as acceptable and accurate by the majority of dietitians participating in the external testing, the response rate was low, limiting the generalisability of the final testing results. The application was modified according to feedback received from dietitians, primarily to make it more user-friendly. Future upgrading will take feedback, or requests from users on the blog, into consideration.

Declaration

Under the InnovUS licensing agreement, the investigator is entitled to *tantieme*, a small percentage of the income generated by the RenalSmart® application.

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