An evaluation of automated dietary assessment: a case study into the development, implementation and evaluation of Computer-Assisted Survey Technology as an adjunct to professional dietary consultation

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Unless otherwise indicated, the views expressed in this thesis are those of the author and do not necessarily represent the views of the University of Wollongong.

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requirements for the award for the degree

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from

UNIVERSITY OF WOLLONGONG

by

YASMINE CHRISTA PROBST

BSc(Nutr), MSc(NutrDiet), GradCertBus, APD

SMART FOODS CENTRE
SCHOOL OF HEALTH SCIENCES
2006
I, Yasmine Probst hereby declare that the work comprising this thesis submitted in fulfilment of the requirements for the award of Doctor of Philosophy for the School of Health Sciences, University of Wollongong, is my own work and the result of original research. To the best of my knowledge it does not contain work previously published by another author unless due acknowledgement has been made in the text. This material has not been submitted for a higher degree at any other University or Institution.

Yasmine Probst

October 2006
This thesis is dedicated to my grandparents
  Günter & Dagmar Meschede
  and
  Wolfgang & Christel Probst

For all the happy times we have shared together
I would like to thank my supervisor Professor Linda Tapsell for her continuing support both academically and professionally throughout the past years. Your assistance has allowed me to grow both as a dietitian and as a researcher and I cannot thank you enough.

Thank you the entire CAST team for their efforts and hard work, you have been a great group to work with, I could not have asked for a better group.

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Thank you to Stuart Parker and John Walter for your assistance during the installation phase of this project. Your handy man skills during the installations were highly appreciated. To Serina Faraji, your help during the implementation phase was priceless and I am forever grateful for your positive attitude and willingness to learn.

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And lastly my greatest thanks to my family especially my mother and father and to my fiancé Greg whose support and understanding have been invaluable throughout the past years, I cannot thank you enough.
Conferences and publications

Peer-reviewed abstracts supporting this thesis


**Non peer-reviewed abstracts supporting this thesis**


**Peer-reviewed papers supporting this thesis**


**Other peer-reviewed papers**


**Prizes and awards**

- Best Oral Presentation: 2005 Dietitians Association of Australia Conference
- 1st place poster presentation for H&BS: 2005 University of Wollongong Higher Degree Student Research Conference
- Best research student for 2005: Smart Foods Centre, University of Wollongong
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7.2 Aims

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7.3.1 Data collection

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<th>Description</th>
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>ADSL</td>
<td>Asymmetric Digital Subscriber Line</td>
</tr>
<tr>
<td>AIHW</td>
<td>Australian Institute of Health and Welfare</td>
</tr>
<tr>
<td>APA(I)</td>
<td>Australian Postgraduate Award – Industry scholarship</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>BMR</td>
<td>Basal Metabolic Rate</td>
</tr>
<tr>
<td>CAPI</td>
<td>Computer-Assisted Personal Interviewing</td>
</tr>
<tr>
<td>CASI</td>
<td>Computer-Assisted Self Interviewing</td>
</tr>
<tr>
<td>CAST</td>
<td>Computer-Assisted Survey Technology</td>
</tr>
<tr>
<td>CATI</td>
<td>Computer-Assisted Telephone Interviewing</td>
</tr>
<tr>
<td>CD</td>
<td>Compact Disk</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CHO</td>
<td>Carbohydrate</td>
</tr>
<tr>
<td>CURF</td>
<td>Confidential Unit Record Files</td>
</tr>
<tr>
<td>DAA</td>
<td>Dietitians Association of Australia</td>
</tr>
<tr>
<td>DASH</td>
<td>Dietary Approaches to Stop Hypertension</td>
</tr>
<tr>
<td>DH</td>
<td>Diet History</td>
</tr>
<tr>
<td>DI</td>
<td>Dietitians Interface</td>
</tr>
<tr>
<td>DVD</td>
<td>Digital Video Disk</td>
</tr>
<tr>
<td>EE</td>
<td>Energy Expenditure</td>
</tr>
<tr>
<td>EI</td>
<td>Energy Intake</td>
</tr>
<tr>
<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
</tr>
<tr>
<td>FR</td>
<td>Food Record</td>
</tr>
<tr>
<td>FSANZ</td>
<td>Food Standards Australia and New Zealand</td>
</tr>
<tr>
<td>g</td>
<td>Gram</td>
</tr>
<tr>
<td>GB</td>
<td>Gigabyte</td>
</tr>
<tr>
<td>GI</td>
<td>Glycaemic Index</td>
</tr>
<tr>
<td>GP</td>
<td>General Practitioner</td>
</tr>
<tr>
<td>HREC</td>
<td>University of Wollongong Human Research Ethics Committee</td>
</tr>
<tr>
<td>IDF</td>
<td>International Diabetes Federation</td>
</tr>
<tr>
<td>IFG</td>
<td>Impaired Fasting Glucose</td>
</tr>
<tr>
<td>IGT</td>
<td>Impaired Glucose Tolerance</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IMM</td>
<td>Interactive Multimedia</td>
</tr>
<tr>
<td>KB</td>
<td>Kilobyte</td>
</tr>
<tr>
<td>kJ</td>
<td>Kilojoule</td>
</tr>
<tr>
<td>L</td>
<td>Litre</td>
</tr>
<tr>
<td>Ltd</td>
<td>Limited</td>
</tr>
<tr>
<td>MB</td>
<td>Megabyte</td>
</tr>
<tr>
<td>mg</td>
<td>Milligrams</td>
</tr>
<tr>
<td>mL</td>
<td>Millilitre</td>
</tr>
<tr>
<td>mmHg</td>
<td>Millimetres of Mercury</td>
</tr>
<tr>
<td>mmol/L</td>
<td>Millimoles per litre</td>
</tr>
<tr>
<td>MUFA</td>
<td>Monounsaturated Fatty Acid</td>
</tr>
<tr>
<td>n</td>
<td>Sample Size</td>
</tr>
<tr>
<td>n-3</td>
<td>Omega-3 fatty acid</td>
</tr>
<tr>
<td>n-6</td>
<td>Omega-6 fatty acid</td>
</tr>
<tr>
<td>NNS95</td>
<td>National Nutrition Survey of Australia 1995</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
</tr>
<tr>
<td>Pty</td>
<td>Proprietary</td>
</tr>
<tr>
<td>PUFA</td>
<td>Polyunsaturated Fatty Acid</td>
</tr>
<tr>
<td>QLD</td>
<td>Queensland</td>
</tr>
<tr>
<td>RDI</td>
<td>Recommended Dietary Intake</td>
</tr>
<tr>
<td>SAQ</td>
<td>Self-Administered Questionnaire</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SES</td>
<td>Socio-Economic Status</td>
</tr>
<tr>
<td>TAFE</td>
<td>Technical and Applied Further Education</td>
</tr>
<tr>
<td>TAM</td>
<td>Technology Acceptance Model</td>
</tr>
<tr>
<td>T2DM</td>
<td>Type 2 Diabetes Mellitus</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UOW</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
</tr>
<tr>
<td>VAS</td>
<td>Visual Analogue Scale</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
</tbody>
</table>
Glossary of terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS codes</td>
<td>Codes given to food items and food groups from the NNS95</td>
</tr>
<tr>
<td>2-digit</td>
<td>= equivalent to CAST categories</td>
</tr>
<tr>
<td>3-digit</td>
<td>= equivalent to CAST subcategories</td>
</tr>
<tr>
<td>4-digit</td>
<td>= equivalent to CAST food types</td>
</tr>
<tr>
<td>Associated food type</td>
<td>A more detailed but still broad grouping of food items that are eaten with the food type items selected</td>
</tr>
<tr>
<td>Associated subcategory</td>
<td>A less coarse grouping of foods that are eaten with the subcategory food items selected</td>
</tr>
<tr>
<td>Associated food</td>
<td>A food item eaten with or on another food item</td>
</tr>
<tr>
<td>AUSNUT</td>
<td>Database of food and nutrient data of 4500 foods consumed in Australia updated regularly by FSANZ.</td>
</tr>
<tr>
<td>Automated assessment</td>
<td>Dietary assessment utilising computer technology</td>
</tr>
<tr>
<td>CAST codes</td>
<td>Unique codes given to food items and food groups for the CAST project to aid with identification</td>
</tr>
<tr>
<td>Category</td>
<td>Very coarse level food grouping for display only on screen. These foods will not be selected by the patient they will simply be a means for sorting on screen</td>
</tr>
<tr>
<td>Computer literacy</td>
<td>The ability to use and/or understand basic concepts relating to computer use and function</td>
</tr>
<tr>
<td>CURF</td>
<td>Confidential Unit Record Files used for the statistical analysis. These files can only be accessed by limited parties and have been obtained from the National Nutrition Survey (NNS95).</td>
</tr>
<tr>
<td>Demographic data</td>
<td>Questions to give a profile of the user including education, SES, anthropometry and computer use. Questions are to be asked after the introduction prior to assessment of intake</td>
</tr>
<tr>
<td>Diet</td>
<td>Intake of foods rather than the restriction of particular food items</td>
</tr>
<tr>
<td>Dietary prescription</td>
<td>Dietary advice prepared by a dietitian sent to the GP of the patient</td>
</tr>
<tr>
<td>Dietitian interface</td>
<td>Nutrient analysis program which accepts the information from the website and analyses the nutrient composition. To be referred to be dietitian during follow up interview.</td>
</tr>
<tr>
<td>Eating pattern questions</td>
<td>Limitations/changes people have made to their food intake e.g. Vegetarian eating. This will also include questions about default types of foods used as a checklist for the dietitian eg milk, oil.</td>
</tr>
<tr>
<td><strong>Follow up interview</strong></td>
<td>Telephone call between the dietitian and the patient to revise/edit information that had been entered into the UI by the patient</td>
</tr>
<tr>
<td><strong>Food frequency</strong></td>
<td>The amount of times a Food Type is eaten during the period of one week. (3w indicates 3 times per week, 3d indicates 3 times per day)</td>
</tr>
<tr>
<td><strong>Food literacy</strong></td>
<td>The level of understanding of foods and their nutrient interactions</td>
</tr>
<tr>
<td><strong>Food type</strong></td>
<td>A more detailed but still broad grouping of food items based on the identifying different types of the same food item. These items will be selected by the user during Pass 3. Not all subcategories will be required to have a food type.</td>
</tr>
<tr>
<td><strong>Introduction</strong></td>
<td>An introduction/welcome to the CAST interface, identification of the user and eating pattern questions</td>
</tr>
<tr>
<td><strong>Meal</strong></td>
<td>Breakfast, lunch, dinner, snacks (morning tea, afternoon tea, supper)</td>
</tr>
<tr>
<td><strong>Pass</strong></td>
<td>Time taken to complete one complete cycle of the meals for one day at varying levels of detail</td>
</tr>
<tr>
<td><strong>Pass 1</strong></td>
<td>Meal frequency questioning</td>
</tr>
<tr>
<td><strong>Pass 2</strong></td>
<td>Sub-category questioning</td>
</tr>
<tr>
<td><strong>Pass 3</strong></td>
<td>Food Type questioning</td>
</tr>
<tr>
<td><strong>Pass 4</strong></td>
<td>Food frequency and portion size questioning</td>
</tr>
<tr>
<td><strong>Portion size</strong></td>
<td>The amount of food that is eaten using the most common measure for the food item e.g. Bread = Slices</td>
</tr>
<tr>
<td><strong>Recipe</strong></td>
<td>A combination of food items or ingredients to compose a dish or meal. To be used in the dietitian interface with default versions that may be modified. These will link with the eating pattern questions to ensure individualisation of the recipe for the specific user</td>
</tr>
<tr>
<td><strong>Subcategory</strong></td>
<td>A less coarse grouping of food items based on common characteristics. These items will be selected by the user during Pass 2.</td>
</tr>
<tr>
<td><strong>Traditional assessment</strong></td>
<td>The manual pen and paper face-to-face dietary interview of the dietitian with a patient</td>
</tr>
<tr>
<td><strong>User interface</strong></td>
<td>Website into which patients enter their dietary information in the GP practice/at home</td>
</tr>
</tbody>
</table>
Executive Summary

Dietary assessment has changed dramatically with time, progressing from face-to-face interviews and hand calculated nutrient intakes to the use of computer technology to automate various parts of the process. The most common application is the use of software packages to calculate nutrient intake data obtained from dietary interviews. The development of technology to automate the interview process will allow for clinicians to spend more time focussing on patient education and counselling. The central hypothesis tested in this thesis was that automated dietary assessment would prove to be a feasible adjunct to the professional consultation in the primary healthcare setting.

Development phase
A series of studies were conducted examining various aspects of computer-assisted survey technology (CAST) applied to dietary advice in the primary healthcare setting. The research is presented as a case study, using action research methodology. Items in the dietary survey were developed from data reduction of food lists reported in the 1995 Australian National Nutrition Survey (NNS95), in conjunction with professional interpretation and judgement. The opinions and beliefs of patients from focus group interviews shaped development of the user interface and a dynamic website was developed to best allow for a diversity of eating patterns.

Testing phase
Video-recorded usability testing found the website to be user friendly with the time taken to complete the survey comparable to the time taken for a dietitian to interview and assess a patient’s food intake. The website was then implemented in the primary healthcare setting over a period of twelve months. Computers were set-up in fourteen medical practices in the Illawarra region of NSW, Australia. Doctors recruited patients with metabolic syndrome to use the website. Data was sent to a dietitian in the research team for development of an individualised dietary prescription, which was then sent back to the doctor to discuss with the patient.
Implementation phase

A cross-section of 200 patients revealed the majority of users were aged between 46 and 65 years, overweight and physically inactive. Computer ownership was identified in 80% of the users, with only 8% of patients having never used a computer previously. The computer located in the medical practice was the least preferred location of use and patients with a higher BMI were 1.9 times (p=0.04) more likely to use the computer in the home or an alternate location than at the medical practice. Reported nutrient data was highly variable. Under-reporting was observed in 46 patients (32.2%), over-reporting in 31 (21.7%) of patients and 66 patients (46.2%) reported their intakes on target. No relationships were found for the reporting status of the patients and their age, BMI or gender.

A repeatability study with n=38 patients revealed a learning effect which led to increased understanding of the website functions with time. Compared to a 3-day weighed food record, data from the website produced stronger correlations than a face-to-face diet history assessment. Patients using the website achieved an average 25% of their dietary goals within six weeks, despite a preference for face-to-face contact with the dietitian. Stakeholder evaluation established acceptance of the technology by dietitians, doctors and patients and provided insights into their positions within the healthcare system.

Evaluation phase

The research found that computerised assessment of dietary intake was a feasible addition to daily practice in the primary healthcare setting. Automating the diet history interview via the internet allowed increased patient access to dietitians whilst improving the doctors’ awareness of the nutrition needs of their patients. This is especially important in the growing light of metabolic syndrome worldwide.