Developing NANA: Novel Assessment of Nutrition and Ageing

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**Introduction**

Nutritional status impacts upon the health and physical function of older people, who face a high risk of nutrient deficiencies and malnutrition. Poor nutritional status is particularly related to loss of skeletal muscle mass and strength, i.e. sarcopenia, which increases both the risk of adverse health outcomes in older people (Fried et al., 2004) and the burden of other diseases (Sequin & Nelson, 2003). Severe sarcopenia is extremely disabling as it prevents independent living and places an increasing burden on healthcare providers.

A number of factors affect nutritional status in older people although the specific relationships are not well understood. Physical factors, such as problems with chewing, swallowing and impaired mobility all contribute towards nutritional decline. Mental health status is another contributing factor, particularly the presence of depression, which has been proposed as the most common cause of weight loss in the ageing population (Morley, 2001). Treating depression can be an effective way of increasing appetite and improving nutritional status. However, it is commonly underdiagnosed and undertreated among older people (Age Concern, August 2007).

There is also growing evidence of associations between diet and cognitive function. Older people with dementia or cognitive decline have a poorer nutritional status than those without (Atti et al. 2008; Requejo et al. 2003; Zekry et al. 2008), with increasing dementia severity related to poorer nutritional status (Riccio, et al. 2007). Nutrients that appear to be of particular importance to cognition include the homocysteine related B vitamins - B12, B6 and folate, antioxidants and polyunsaturated fatty acids (Rondanelli et al. 2007, Van Dyk & Sano 2007). The potential for diet to protect against cognitive decline in older people is not currently well understood and much of this research is epidemiological (Malouf et al. 2003, Lim et al. 2006).

Both intervention and prospective cohort studies are needed to explore the associations and interactions between mental and physical health and diet (Psaltopoulou et al. 2008). One challenge of such research is that ageing and the accompanying cognitive and physical decline are both progressive and dynamic. Existing tools for measuring diet, cognition and physical activity provide only snapshots of the situation and cannot identify rate of decline nor readily distinguish cause and effect.

Most dietary assessment methods rely upon a pen and paper approach and require participants to recall and record what they have eaten. These are often unsuitable for use with older people, especially those with memory loss or other impairments (Bowman & Rosenberg 1982). Multidimensional assessment covering nutrition; function in activities of daily living; cognition; and mental health would enable effective targeting of interventions (Balducci & Beghe, 2000). The aim of the NANA project was to develop such a comprehensive assessment using technology to facilitate collection of detailed information from a cross-section of older people and reduce the burden placed on participants by daily data collection. The intended outcome was a single integrated toolkit for use by practitioners and researchers concerned with the health and well being of older people.

**Aims and methods of the research**

To achieve the aims of the NANA project a multidisciplinary team combining expertise in the psychology of ageing, human nutrition, medical engineering (including mechanical and electrical) and human-computer interaction (HCI) was assembled. This included three postdoctoral and one masters level researchers, two PhD students, and four early-career academics. In addition, 3 Masters level and 3 undergraduate students participated in the project at different times. The NANA programme of research was planned to take place over three years and was organized into three phases. These are each described briefly below with the full list of studies summarised in Table 1.

Table 1: Compendium of studies completed during NANA project

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Phase | Study | N | Participants (age range) | Purpose | Data |
| Phase 1: User Needs Analysis | | | | | |
| 1 | 1. Focus group | 7 | Older adults (66-85years) | To explore participants’ attitudes to new technology generally and also to diet and health assessments. | Video + transcript |
| 1 | 2. Focus group | 7 | Older adults (65-85) | To explore attitudes to diet and health assessments, dietary recording inside and outside home, and new technologies, including PDA, mobile phone, and tablet PC. | Video + transcript |
| 1 | 3. Focus group | 8 | Older adults  (65 – 85+) | To explore views of touch screens, mobile phones, digital scales, dietary recording at home and in public including photographing and audio recording, mock-ups of the NANA system attitudes to activity monitoring using technology, | Video + transcript |
| 1 | 4. Focus group | 5 | Nutritionists | To explore challenges in collecting accurate information on food and drink intake in the community, propose improvements, suggest measurements for NANA toolkit. | Video + transcript |
| 1 | 5. Focus group | 6 | Nutritionists | To explore challenges in collecting accurate information on food and drink intake in the community, propose improvements, suggest measurements for NANA toolkit. | Video + transcript |
| 1 | 6. Focus group | 7 | Health professionals | To examine obstacles and gaps in current practice and information needed for assessing diet in the community, suggestions about measurements for NANA system. | Video + transcript |
| 1 | 7. Focus group | 7 | Health professionals | To examine obstacles and gaps in current practice and information needed for assessing diet in the community, suggestions about measurements for NANA system. | Video + transcript |
| 1 | 8. Field study | 2 | Older adults (75-85) | To evaluate currently available smart phones on the high street |  |
| 1 | 9. Field study | 6 | Older adults  (65+) | To investigate the feasibility of older adults recording dietary intake data using digital cameras. | Photographs + questionnaire + 24-hour multiple pass recall |
| 1 | 10. Field study | 2 | Older adults (73-75) | To investigate the feasibility of older adults recording dietary intake data using a Flip video camera. | Video recordings + questionnaire |
| 1 | 11. Field study | 8 | Older adults 65-85+ | To inform the design of the NANA home station physical user interface using MDF mock-ups | Questionnaire and freeform comments |
| 1 | 12. Field study | 3 | Older adults (71+) | To identify preferable size for touch screen to have in home environment | Video + transcript |
| 1. | 13. Field study | 2 | Older adults  (75) | To examine the usability of a wearable activity assessment tool (i.e. HTC Activity software) | Questionnaire |
| Phase 2: Development of Integrated Measurement Toolkit | | | | | |
| 2 | 14. Grip strength (1) | 16 | Adults (20-60) | Comparison of high quality hand dynamometer with low cost dynamometer that could be modified for inclusion in the NANA system. | Grip strength in Newtons |
| 2 | 15. Grip strength (2) | 7 | Adults (28-53) | Test of Variance in Grip Strength over a period of 1~2 weeks | Grip strength in Newtons |
| 2 | 16. Grip strength (3) | 7 | Older adults (65-85) | Test of Variance in Grip Strength over a period of 1~2 weeks | Grip strength in Newtons + questionnaire |
| 2 | 17. Beam breakers (a)  (b) | 17  3 | Adults (24-63)  Adults (25-40) | To user-evaluate technical approaches to measuring walking speed in domestic environments. Long term testing in office environment  Technical evaluation to test feasibility in domestic environment. | Walking speed and questionnaire  Walking speed |
| 2 | 18. ‘Piezo’ sensors – feasibility study | n/a | n/a | To investigate the feasibility of creating a self=powered in-shoe gait sensor | Feasibility Report |
| 2 | 19. Activity monitoring | 2 | Older adults (65+) | To examine the usability of a wearable activity assessment tool (i.e. HTC Activity software) | Questionnaire + step data |
| 2 | 20. Weigh-mat Trial | 7 | Older adults (65-85) | To evaluate the use of a weighing device to be integrated into the NANA system | Questionnaire + food photographs |
| 2 | 21. Food weighing | 3 | Older adults (65+) | To evaluate early version of NANA with Kern scales and barcode scanner | Questionnaire |
| 2 | 22. Measuring error of data entry | 2 | Nutritionists | To determine the repeatability of entering a food diary by 2 different researchers. | 4-day estimated food diary |
| 2 | 23. Food Frequency report (1) | Database of 217 older adults | Older adults (65-85)  Adults | To create a list of foods commonly consumed by older adults using data previously collected from a South Yorkshire population of older adults. | 4-day estimated food diary |
| 2 | 24. Food Frequency report (2) | 40 | Older adults (65+) | To investigate the differences in the accuracy of dietary information collected using a food frequency questionnaire (FFQ) compared to an estimated food diary using data previously collected from a South Yorkshire population of older adults. | 4-day estimated food diary + FFQ |
| 2 | 25. Food tree (1.1) | 15 | Older adults  (65+) | To develop software for a touch screen computer based dietary recording system a) Generation of a hierarchical tree structure containing food and drink items. | Card sorting categories |
| 2 | 26. Food tree (1.2) | 15 | Older adults (65+) | To develop software for a touch screen computer based dietary recording system b) Development of a suitable software platform. | Questionnaire and observation |
| 2 | 27. Food tree (2) | 10 | Older adults  (65+) | Testing of the touch screen computer based dietary recording system | Food entry data + questionnaire |
| 2 | 28. Portion size | 40  41 | Older adults (65+)  Adults (18-40) | To investigate the ability of older adults to assess portion size compared with younger adults. | Portion size data + medium (screen vs book) |
| 2 | 29. Cognition and mood study | 48 | Older adults (65-89) | To develop and test new measures of mood and cognitive function for use in the NANA system | Pen and paper data + responses to 12 new cognitive tests + mood measure |
| 2 | 30. Gait measurement validation | 6 | Adults (24-37) | To validate gait data collected by manual analysis of video recording against a mechanical stop-clock. | Gait + cognitive data |
| 2 | 31. ‘Bigfoot’ validation study | 6 | Older adults (66-91) | To validate the ‘Bigfoot’ gait analysis system against the manual analysis of data from video-recordings | Gait + cognitive data |
| 2 | 32. Configuration study 1 | 2 | Older adults (75-85) | To examine practicalities of recording meals over six days using early food tree software, mobile phone camera, weigh mat | Questionnaire |
| 2 | 33. Configuration study 2 | 3 | Older adults  (75-85) | To examine tolerance for recording meals for varying amounts of days using early food tree software, mobile phone camera, weigh mat | Questionnaire |
| 2 | 34. Configuration study 3 | 3 | Older adults  (65-85) | To examine functionality of revised configuration using commercial scales and webcam, with modified food tree and additional features | Questionnaire |
| 2 | 35. Configuration study 4 | 10 | Older adults  (69-86) | To try out latest version of food tree entering previous day’s food, without photographs or weighing | Questionnaire |
| 2 | 36. Validation study (1) | 40 | Older adults (65-86) | To validate a novel method of dietary assessment (NANA) for use with older adults. | Food entry data + 4-day estimated food diary + three 24 hour Multiple pass recall, biomarkers + questionnaire |
| 2 | 37. Validation study (2) | 19 | Older adults (65+) | To validate a novel method of dietary assessment, mood and cognitive function (NANA) for use with older adults. | Food entry data + cognition and mood data 4-day estimated food diary + biomarkers + questionnaire |
| 2 | 38. Dual task | 72 | Older adults  (65-91) | To explore the relationship between gait and cognition over time | Gait + cognitive data over 12 months |
| Phase 3: Full Validation of the NANA Assessment Toolkit | | | | | |
| 3 | 39. Validation study 3 | 40 | Older adults  (65-89) | To validate a novel method of dietary assessment, mood, cognitive function and physical activity (NANA) for use with older adults | Food entry data + cognition and mood data + physical activity data + 4-day estimated food diary + biomarkers + questionnaire |
| 3 | 40. Datagait study | 36 | Older adults (65-88) | To validate Datagait against manual methods of recording gait in the home and in a clinical setting | Gait data |
| 3 | 41. Steadying gait | 45 | Older adults (65-88) | To examine the potential for steadying gait and improving cognitive function | Gait + cognitive data |
| 3 | 42. NANA focus group | 8 | Older adults (64-85) | To identify how the NANA data could best be used to support older adults and who it should be shared with. | Narratives |

Phase 1: User Needs Analysis

The first phase of the project comprised engagement through focus groups with the two key target groups of users: (i) older people who might use the NANA toolkit in their own homes as patients or research participants; and (ii) health professionals likely to use the toolkit for clinical or research purposes. Older adult volunteers were recruited via advertisements in GP surgeries, local community groups and organisations responsible for the care of older people.

Seven focus groups (Studies 1-7, Table 1) were run in total – three with older adults, two with nutrition professionals and two with other health professionals. Each group was organised and run by two members of the NANA project team representing different disciplines. For example the HCI researcher and mechanical engineer each attended one nutritionist, one health professional and one older people’s focus group. This was to ensure that all members of the team had a good grasp of the concerns raised by the older adults and health professionals and of the challenges to be overcome in developing the NANA system. The focus groups were video and audio recorded then transcribed for Thematic Analysis.

The older people included healthy community dwelling individuals living in their own homes or in extra care accommodation and were drawn from three different areas of the UK (Scotland, South West England and South East England). A total of 11 nutritionists attended the two nutrition focus groups, one in the South East of England one in the North East. The majority of participants were nutrition researchers who were well versed in currently available measures and techniques for collecting dietary information in the community and the limitations of these. Fourteen health professionals participated in the two health focus groups, which were both held in Scotland. These comprised four dietitians, two occupational therapists, one research nurse, one daycare service manager, one patient and public NHS representative, one health worker, one social worker, one old age psychiatrist, one geriatrician, one clinical psychologist and one member of staff from a community meals service. The multidisciplinary nature of these two focus groups also permitted discussion of the different roles played by different professionals in identifying and supporting older adults with nutritional problems in the community and also the inter-professional communication and common methods of interacting and sharing information.

Additionally, Phase 1 also included five field studies (Studies 8-12, Table 1) with older adults. The first was to evaluate currently available smart phones on the high street, the second was to examine the feasibility of asking older adults to record their food and drink using digital photography and the third explored the same question using a Flip video camera. The fourth was to explore older adult’s reactions to early ideas for the NANA interface using mock-ups and the fifth examined the acceptability of and preferences for different sized touch screens in the home. Study 13 in Phase 1 looked at the usability of a wearable activity assessment tool.

Phase 2: Development of Integrated Measurement Toolkit

This phase of the project was informed by the findings from Phase 1 and comprised three integrated strands: (i) iterative design and development of the measurement toolkit, (ii) dietary validation studies; and (iii) cognition & mental health validation studies. These three strands were carried out synchronously to place the NANA toolkit in the context of existing measures of nutrition, physical activity, mental health, and cognitive function.

Phase 2.1: Toolkit Development

This strand focused on the design and development of the measurement toolkit, strongly influenced by the findings of the user needs analysis. The design of the technology and the experimental protocols required close collaboration between the clinical (psychology and nutrition) and technical (electrical, mechanical and HCI disciplines). The technical members of the team provided problem solving skills and guidance on technical feasibility to the clinicians, who in turn provided detailed information to the engineers on what parameters should be measured and guidance on the design of the user interface for the measurement and data processing technology.

During this phase the nutrition team worked closely with the technical team to develop the novel tools for monitoring dietary intake (see Phase 2.2 below) and in particular with the HCI researcher to explore methods of streamlining the entry and analysis of the dietary intake data. The validity and feasibility of the software solutions developed were tested extensively. The McCance & Widdowson Composition of Foods Integrateddataset (http://tna.europarchive.org/20110116113217/http:/www.food.gov.uk/science/dietarysurveys/dietsurveys) and the photographic atlas of food portion sizes (Nelson et al 1997) were used.

The psychology team worked on developing and validating novel measures for assessing and monitoring cognitive function and mental health. Two key issues relating to developing novel methods for repeated use over time informed this work: (i) reliability and (ii) repeatability. The psychology team also worked with the nutrition team on developing methods for collecting information on physical function and with the HCI team on methods to integrate this information with the cognition and mental health measures. Additionally the technical team took the lead on developing a means of recording grip strength within the NANA toolkit.

An integral and substantial part of the toolkit development was the design and integration of the technology to make in-home measurements of parameters such as nutritional intake, activity levels and grip strength (Studies 14-21, Table 1). To ensure the technology fitted closely around the capabilities and preferences of the intended users an iterative design process was applied. This included building prototypes at an early stage in the development process that were shown to, used and evaluated by a panel of users and professionals in the study sites in the South East and South West of England. Feedback from this panel guided the design of the second and third iterations of the system (Phase 2, studies 32-34) The fourth (Study 35) iteration focused less on design, and more on integration of the components into a functional system where data can be shared and stored in one place for easy access and analysis. The technology design phase concluded with the deployment of sufficient NANA toolkits to support 20 people using the system concurrently.

Phase 2.2: Dietary Validation Studies

This phase of the project comprised a number of studies that together contributed to the development of the novel dietary assessment method in the NANA toolkit. This included studies relating to the development of the NANA dietary entry system (Studies 22-28, Table 1). These individual studies were designed to answer questions relating to accuracy of food data recording and analysis, furthering understanding about portion size measurement and creating a food tree for the food entry system.

2.2.1 First validation – diet only (Study 36, Table 1)

In this first of three validation studies 40 older adults (over the age of 65 years) were recruited in one centre in the North of England. Participants recorded their diet using three different assessment methods. Three 24 hour multiple pass recalls were conducted, participants were then asked to record their diet for 3 weeks using the NANA system. A fasted blood sample and a 24-hour urine collection were collected from each participant during the second week of recording their diet with the NANA system. Following a 3-week washout period participants then completed a 4 day estimated food diary. Four days of dietary intake data for the NANA and the diary method and three days intake data for the recall method was entered and analysed using Windiets (version 2010). Biological samples were used for the analysis of biomarkers of nutrient intake (plasma vitamin C, retinol and carotenoids and urinary urea)

Phase 2.3: Cognition and Mental Health Validation Studies

This phase of the project focused on developing a comprehensive assessment of mental health and cognitive function in older people. Standardised measures of cognition were used to identify tasks that were valid and reliable with repeated use. In addition, the length of the individual measures, time to complete and ease of completion plus acceptability to older people was considered. These were evaluated alongside a measure of physical function used to identify frailty (Fried, 2005). The intention was to identify elements that are critical for inclusion in a comprehensive assessment that covers physical function as well as cognition and mental health.

Specific studies conducted in Phase 2 included the development of 12 candidate cognitive tasks and a novel method for self-reporting mood (Study 29) administered through a touchscreen computer. This involved 45 older adults attending for three appointments to examine repeatability and validity. From these the two most sensitive cognitive tasks plus a daily mood measure were selected for inclusion in the NANA toolkit. Further studies were designed to develop methods for collecting accurate data on gait that could be used in the home environment (Studies 30 & 31) and a measure for examining the relationship between gait and cognitive function (Study 38).

Phase 2.4 Second validation – diet & cognition

In this second validation study (Study 37, Table 1) nineteen older adults from the North East of England were recruited, 17 of who lived in a purpose built continuing care retirement community. Participants completed a total of three 24-hour recalls, one four-day estimated food diary, and ten days recording dietary intake using the NANA system. They also completed daily assessment of cognition and mood using the NANA system and a battery of standardised pen and paper cognitive tests and a standardised depression scale. Data derived from the NANA system was assessed against that obtained via the estimated food diary method. Acceptability of the NANA system was ascertained via the responses given in a feedback questionnaire.

Phase 3: Full Validation of the Assessment Toolkit.

The third phase of the project was the main validation study (Study 39, Table 1) to compare the NANA toolkit with the best ‘pen and paper’ methodologies identified in Phase 2 and against independent biochemical markers of nutrient status. Forty participants, 20 in North England and 20 in Scotland, were recruited comprising a cross-sectional group of older people living in their own homes or extra care accommodation in the community. Cross-centre training took place to ensure all methodologies were applied correctly in the two sites where the validation study took place. Participants were asked to use the NANA toolkit for 3 separate one-week periods; each one-week period of use was followed by a three-week wash out period. The NANA system was used to collect data on food and drink consumed, cognitive function, mood and physical activity, plus grip strength. A fasted blood sample and a 24-hour urine collection were collected from each participant during the second week of recording their diet with the NANA system. Following a 3-week washout period participants then completed a 4 day estimated food diary. Participants completed a standardised cognitive test battery, depression scale and physical activity questionnaire at the start and end of the study. Four days of dietary intake data from each method was entered and analysed using Windiets dietary analysis software (version 2010, Windiets Research, Robert Gordon University, Aberdeen, UK). Statistical analysis was carried out using SPSS. Biological samples were used for the analysis of biomarkers of nutrient intake (plasma vitamin C, retinol and carotenoids and urinary urea)

Additional studies conducted in Phase 3 included a comparison of methods of collecting gait data in the home setting (Study 40, Table 1). A further study (Study 41, Table 1) looked at the potential for steadying the gait of older adults through a novel intervention that could be completed in the community. The final study (Study 42) was a focus group attended by eight older adults and 2 staff members from a health and social care service to discuss the potential application of the data collected by the NANA system.

**Findings**

Phase 1: User Needs Analysis

The three focus groups with older adults informed the development of the technology in the NANA toolkit and illuminated issues relating to monitoring and assessment of concern to older adults. For example, there was wariness among older adults about being monitored remotely and use of the Internet to share data. The two groups with nutritional professionals focused on current limitations to collecting good nutritional information in the community and generated a ‘wish list’ that they would like to see from the NANA system. Similarly the two groups of health and social care professionals also produced a ‘wish list’ for NANA and highlighted the limitations of current approaches to assessment and support of nutritional concerns in the community. They also noted the importance of inter-professional communication and the need for shared language for supporting people with complex needs living in the community.

Phase 2: Development of Integrated Measurement Toolkit

Phase 2.1: Toolkit Development

The data from the iterative development studies informed the design of the NANA interface and additional items in the toolkit.

Phase 2.2: Dietary Validation Studies

The various studies conducted in this Phase of the project informed the development of the dietary entry interface in several ways. First we extended our understanding of the suitability of digital photography as a means of recording dietary intake in older adults. Additionally, we learnt about the sources of differences between different researchers entering food data and how to avoid these. The results of the Food Frequency studies suggested firstly that dietary assessment methods should be specifically designed for the target population and secondly that there is major variation between the calculations of food intake between the Food Frequency Questionnaire and diary method. This suggested that a Food Frequency Questionnaire style dietary assessment method is not suitable and a more detailed method needs to be used for dietary assessment in older adults. The food tree study enabled us to develop a hierarchical tree structure with a satisfactory number of items suitable for use within the older adult population. Finally, the portion size study revealed that estimating portion size is particularly difficult for certain food types and needed to be addressed by the NANA system.

Phase 2.3: Cognition and Mental Health Validation Studies

The results of the cognition and mood study suggested that two novel tests of cognition had both high acceptability and good sensitivity when compared with standard pen-and paper measures. These two tests were included in the next iteration of the NANA system, along with a simple mood measure that also had high acceptability among participants. The gait studies informed decision-making about how to collect gait data in the home environment.

Validation studies

The first validation study suggested that NANA may be a suitable alternative to estimated food diaries in older adults as the results correlated with a four-day food diary in respect of energy, carbohydrates, protein, fat and vitamin C. The second validation combining dietary intake and cognitive and mood measures reinforced the findings of the first validation in regarding the reliability of the dietary data collection. The cognition and mood measures had high acceptability from the participants with over 99% of trials completed.

The third validation study confirmed the suitability of the NANA system for collecting dietary data from older adults with positive correlations both with a four-day food diary and biomarkers for nutrition intake. There was also high acceptability of the cognitive and mood measures and of a simple measure of physical activity. The data on grip strength suggested that, like the cognitive and mood data, it is possible to collect these data without a researcher being present.

***Implications in terms of policy, practice and/or product development***

The complexity and comprehensiveness of the NANA project mean that it has yielded large amount of results, which have implications and relevance for a number of domains. In addition, the multidisciplinary and multidimensional aspects of the NANA project have ensured that the findings are accessible to a wide range of audiences and potential beneficiaries.

The key findings in relation to the main aims of the NANA project to collect data on nutrition, cognition, mood and physical function are that (i) older adults are happy to use new technology in their own homes; (ii) older adults are comfortable recording what they eat and drink on a daily basis; (iii) older adults are prepared to record their mood on a daily basis; (iv) older adults will complete cognitive measures on a daily basis; and (v) older adults will record their physical activity and function using new technology.

The measures used in NANA were validated against currently available gold standard measures for diet, cognition, mood and physical activity. The validation studies demonstrated that the data collected in NANA were at least as good as those collected by currently available methods. Other key findings included demonstrating that reliable cognitive assessment can be achieved without a researcher being present.

The research showed that it is possible to collect reliable data in people’s homes with the potential for early detection of change in any of the NANA domains. The research has also demonstrated that NANA is an accessible and acceptable technology for a wide range of older adults. NANA can be used to collect data that is as good if not better than pen and paper methods and reduces the burden on participants, resulting in high compliance in data recording. These findings should be of interest to nutritionists and other researchers in the field who wish to collect longitudinal data in older people’s homes.

In respect of possible practice implications, the findings from the NANA research project highlight the potential for early detection and intervention not only for older people at risk of malnutrition but also frailty, cognitive decline and mood disorders. By monitoring over time and looking for changes in an individual’s functioning, an individual could receive a suggestion to attend their GP, to whom the data could also be sent. Additionally, the data collected by NANA can be fed back to older adults themselves, to facilitate self-management as many participants expressed a desire to “see how I am doing”. The data collected could also be shared with family members to form the basis of discussion and provide reassurance. Older adults also saw the benefit of collecting prospective data and like the idea that someone would keep track of them and be alert to any significant changes in their profile.

This latter point links to the policy implications of NANA in respect of the potential for establishing prospective monitoring of older adults, particularly those identified as being at particular risk of

health conditions associated with ageing. In addition to the immediate benefits to the current generation of older adults, the information collected would provide a large data set to profile the emergence of some of the major health conditions associated with ageing. Additionally, NANA heralds the way for the functionality of new technology and the availability of holistic assessment to support people to live and age as well as possible.

***Conclusion summarising the key points, highlighting significance for ageing research, policy and practice, and indicating the next steps for research.***

The primary project output is a validated toolkit for the measurement of nutrition, cognitive function, mood and physical activity of older people. Outputs directly related to the toolkit include the data from the user needs analysis, the individual nutrition, cognition, mood and physical activity studies, and the validation studies. Additionally, the technology developed in the project is suitable for measuring the impact of other interventions on physical and mental health. The toolkit could be used to measure the impact of, for example, pharmacological and exercise interventions or it could be used in a clinical assessment context. It could also be adapted for use with children, people with particular health needs or used to measure the impact on physical and mental health of assistive technology interventions.

In respect of the next steps in research major funding is being sought to conduct at least one intervention study to assess the efficiency of NANA in detecting change and monitoring the impact of a given intervention. In addition, the NANA team are also working with a number of food and care providers to develop the outputs from the system and answer questions about how to integrate the NANA data into services.

References

Age Concern. (2007). Undiagnosed, untreated, at risk: The experiences of older people with depression.

Atti, A. R., Palmer, K., Volpato, S., Winblad, B., De Ronchi, D., & Fratiglioni, L (2008). Late-Life Body Mass Index and Dementia Incidence: Nine-Year Follow-Up Data from the Kungsholmen Project. JAGS, 56(1), 111-116.

Balducci., L& Beghe, C. (2000). The application of the principles of geriatrics to the management of the older person with cancer. Critical reviews in oncology/ hematology, 35(3): 147-54.

Bowman BB, Rosenberg IH. (1982). Assessment of the nutritional status of the elderly. American Journal of Clinical Nutrition,*.*May;35(5 Suppl):1142–1151.

Fried L P, Ferrucci L, Darer J. *et al* Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. J Gerontol A Biol Sci Med Sci 2004. 59M255–M263.M263.

[Lim WS](http://www.ncbi.nlm.nih.gov/pubmed?term=Lim%20WS%5BAuthor%5D&cauthor=true&cauthor_uid=16437528), [Gammack JK](http://www.ncbi.nlm.nih.gov/pubmed?term=Gammack%20JK%5BAuthor%5D&cauthor=true&cauthor_uid=16437528), [Van Niekerk J](http://www.ncbi.nlm.nih.gov/pubmed?term=Van%20Niekerk%20J%5BAuthor%5D&cauthor=true&cauthor_uid=16437528), [Dangour AD](http://www.ncbi.nlm.nih.gov/pubmed?term=Dangour%20AD%5BAuthor%5D&cauthor=true&cauthor_uid=16437528). (2006). Omega 3 fatty acid for the prevention of dementia. Cochrane Database Syst Rev, Jan 25;(1):CD005379.

Malouf R, Grimley EJ. (2003). Vitamin B6 for cognition. Cochrane Database Syst Rev;(4) CD004393

Morley J.E. (2001). Anorexia, sarcopenia, and aging. Nutrition,17(7-8): 660-3.

Nelson M., Atkinson M., Meyer J (1997) A photographic atlas of food portion sizes. London: Food Standards Agency.

Psaltopoulou T, Kyrozis A, Stathopoulos P, Trichopoulos D, et al. (2008). [Diet, physical activity and cognitive impairment among elders: The EPIC-Greece cohort (European Prospective Investigation into Cancer and Nutrition).](http://cirrie.buffalo.edu/database/97459/) *Public Health Nutrition* 11(10):1054-1062.

A M Requejo, A. M., R M Ortega, R.M., Robles, F., Navia, B., Faci, M., & Aparicio, A., (2003). Influence of nutrition on cognitive function in a group of elderly, independently living people. *European Journal of Clinical Nutrition* (2003) **57,** Suppl 1, S54–S57.

Riccio, D., Solinas, A., Astara, G., Mantovani, G. (2007). Comprehensive geriatric assessment in female elderly patients with Alzheimer disease and other types of dementia. Archives of gerontology and geriatrics, 44 Suppl 1: 343-53

Rondanelli, M.,Trotti, R., Opizzi, A., Solerte, S. B. (2007). Relationship among nutritional status, pro/antioxidant balance and cognitive performance in a group of free-living healthy elderly. Minerva Med. 2007 Dec;98(6):639-45.

Sequin, R., & Nelson, M. E. (2003). The benefits of strength training for older adults. American Journal of Preventive Medicine. 2003 Oct; 25(3) Suppl 2: 141-9

Van Dyk K, Sano M. The Impact of Nutrition on Cognition in the Elderly. Neurochemical Research 2007; 32(4-5): 893-904.

Zekry, D., Herrmann FR, Grandjean R, Meynet MP, Michel JP, Gold G, Krause KH (2008). Demented versus non-demented very old inpatients: the same comorbidities but poorer functional and nutritional status. Age Ageing. Jan;37(1):83-9.