Design, development, and evaluation of the Maternal Outcomes and Nutrition Tool (MONT)

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Abstract

Suboptimal nutrition has been largely associated with poorer perinatal outcomes. However, an inability to compare data between biologically and geographically diverse cohorts has complicated determination of the role of diet in such conditions. The aim of this paper is to describe the design, development, and evaluation of the Maternal Outcomes and Nutrition Tool (MONT), a novel cross-cultural digital dietary data collection tool. The tool was modelled on previously validated food frequency questionnaires and designed for exclusive administration in the digital environment, featuring minimal language and emphasis on images. Participants were recruited by both passive and active means. A total of 502 women were recruited; descriptive statistics were used to describe the cohort. Pregnant women constituted the majority of subjects recruited ($n = 376$, 74.9%), 63% of which were nulliparous. Women were recruited from 13 ethnicities and 20 countries of birth. Of the 341 women who commenced the surveys (68%), 114 submitted complete datasets (33.5%). Maintenance and recruitment costs equated to \$5.64 per completion. Total processing and analysis time for the pilot dataset equated to 12 s per survey. The MONT was used successfully by women from a variety of continents and cultures and proved to be practical and economical in terms resource management.

1 | INTRODUCTION

Suboptimal nutrition is a public health risk reported by almost every country worldwide. Globally, up to 3 billion people are malnourished because of limited access to food, over nutrition, or micronutrient deficiency (Hovdenak & Haram, 2012). The Global Nutrition Report 2014 identified the need for comparability across countries and proposed measures to address these issues, among which were the improvement of existing and development of new nutrition-related data collection instruments and methodologies (International Food Policy Research Institute, 2014).

In a multifaceted strategy designed to address global issues, the United Nations (UN) launched their Millennium Development Goals (MDG)—specifically MDG 4 and 5—a 25-year plan aimed at reducing child mortality and improving maternal health. Although the MDG made significant progress toward these aims, deficits in data quality

were highlighted by the World Health Organisation (UN, 2015). In support of and subsequent to the MDG, the sustainable development agenda was created (UN, 2016), with reproductive information collection and dissemination remaining a priority in the global context (International Food Policy Research Institute, 2014; UN, 2015).

Distance to travel for care provision, an inadequate ratio of health providers to women and limitations in data collection tools are among the most pressing obstacles in addressing the shortfalls identified by these agencies and result in a lack of diversity in data collection (UN, 2015). Digital solutions, such as mobile applications (mHealth) and electronic delivery (eHealth), are becoming increasingly relevant in point-of-care data collection (Tripp et al., 2014) with the capacity to enhance engagement with health care and related research in logistically challenging regions.

Further, the need for minimal personnel and financial resources in the implementation, evaluation, and analysis of large-scale data

collections may prove beneficial in the planning and management of such initiatives (van Velthoven, Car, Zhang, & Marušić, 2013). Digital data collection formats also facilitate flexibility, in that the information may be declared by the patient (self-reported) or by health care workers (HCWs) at point-of-care, by desktop or laptop computer, tablet, or smartphone.

Food frequency questionnaires are widely used in epidemiological studies to categorise individuals into varied levels of nutrient consumption and to determine relationships between diet and health outcomes (Barbieri, Nishimura, Crivellenti, & Sartorelli, 2013). These tools have been proven valid and reliable in a variety of populations (Barbieri et al., 2013; Brantsæter et al., 2007; Mouratidou, Ford, & Fraser, 2006). However, the value of data collected by these tools is limited in the global arena, due to validation being population or nutrient specific, differing collection parameters and analysis methods, small sample cohorts, and by inevitable linguistic and sociocultural inflexibility (Barbieri et al., 2013). The traditional pen-and-paper format of such tools has been demonstrated to be time consuming and complex, producing fragmented and incomplete data (Zhang et al., 2012). Further, administration of these surveys requires trained personnel, an activity severely restricted by the current staff shortage and the expense involved in researcher education (van Velthoven et al., 2013). These factors have resulted in the inability to integrate and compare dietary data between populations (Detours, Dumont, Bersini, & Maenhaut, 2003; Dwarkanath et al., 2014; Higginbottom et al., 2011; Scales, Krogstrand, Albrecht, & Eskridge, 2013; van Velthoven et al., 2013), a necessity in the cross-validation of datasets derived from biologically diverse cohorts (Detours et al., 2003).

Given potential advantages in the collection, collation, and dissemination of information, the development and implementation of a cross-cultural, standardised, flexible, and comprehensive digital dietary data collection tool, which facilitates integration and cross-validation, would be invaluable in supporting targets for real-time, inter-operative data collection on a global scale. Although development of such a tool presents significant challenges, examples of a single data collection tool examining cause and effect applied across international cohorts exist (Chappell et al., 2013; Wheeler, Feetam, & Harrison, 2014). These have been utilised across populations with differing social and cultural profiles reporting reliable and usable data. Tools designed around this premise may also prove to be beneficial in diverse populations through multiple language options (Tomlinson et al., 2009) and may eliminate interviewer bias, increase sample size, and facilitate access to isolated populations. This may provide an avenue for real-time ongoing data collection (van Velthoven et al., 2013) and an ideal model for both self-reporting and HCW data collection in rural and remote locations (Fee & Griffith, 2013). Such an application has the capacity to support UN and World Health Organisation targets with relation to technological advances and data collection in the reproductive setting.

The aim of this paper is to describe the design, development, and evaluation of the Maternal Outcomes and Nutrition Tool (MONT), a novel digital dietary data collection tool designed for administration solely in the online environment.

Key messages

- Food frequency questionnaires are widely used in epidemiological studies; however, data collected by these tools are limited by their inability to integrate and compare dietary data between populations.
- This is a necessity in the cross-validation of datasets derived from biologically and geographically diverse cohorts.
- This paper adds findings related to the collection of nutrition-related data from pregnant women by use of a novel cross-cultural digital data collection tool.
- The Maternal Outcomes and Nutrition Tool was used successfully by women from a variety of cultures and proved to be practical and economical in terms resource management.

2 | METHODS

2.1 | Study design

The research was conducted in pregnant women aged 16–44 living on the Gold Coast, Australia. Awareness of the project was enhanced by means of promotion and publicity, including word of mouth, in-hospital advertising, and social and traditional media. Participants were subsequently recruited to this project by two means—passive and active. Passive recruitment involved women opting into the research via a women's health and pregnancy information website designed specifically as a vector for the project. Women recruited by this method required no direct face-to-face engagement with the research team and encouraged women to self-select participation and submit their information to the research database. Actively recruited women were approached in the antenatal setting and consented for participation. Neither group was provided any researcher or HCW assistance with completion of the surveys. Data pertaining to women recruited between the project's launch on May 24, 2016, and September 30, 2016, were isolated for analysis and considered the trial phase. Performance of the MONT in the subsequent year was also investigated. The timeframe in its entirety constituted the pilot study (May 24, 2016, to September 30, 2017). Data analysis investigated a number of aspects of the MONT, including cohort characteristics, engagement with culturally and linguistically diverse (CALD) populations, and the economy of the tool with regard to resource management. Active recruitment commenced on September 4, 2017, and data from participants to September 30, 2017, have been included in this analysis.

2.2 | MONT design

The MONT was designed for exclusive administration in a digital format. The format was adaptable to desktop and mobile applications, mouse or touch screen devices, participant self-selection,

and/or HCW-facilitated completion. A registration component was created to capture contact details for follow-up purposes, including username, password, reproductive status (not pregnant, planning or trying, and pregnant), referral source, country, and postcode. This enabled unique participant identification, investigation of individual communities by postcode, and direction of participants to the relevant survey set. Indication of consent was mandatory for successful registration.

Food frequency surveys in the MONT were adapted from the previously validated Norwegian Mother and Child (MoBa) Study (Brantsæter, Haugen, Alexander, & Meltzer, 2008) with reference to the Harvard (Willett et al., 1985) and the Block (Boucher et al., 2006) food frequency questionnaires and the diet history questionnaire (Subar et al., 2001). The survey assessing the motives influencing food choice was adapted from Steptoe, Pollard, and Wardle's Food Choice Questionnaire (Steptoe, Pollard, & Wardle, 1995).

Surveys were designed with a minimal language component, relying rather on numerical characters and easily recognisable images embedded into each question. This strategy was intended to minimise the influence of language barriers in women from CALD backgrounds and create an engaging design. Surveys containing subcategories were constructed with conditional logic. In this respect, the participant was presented with a dichotomous (yes/no) question prior to being offered the list of associated options. This affected an opt-in, allowing those who do not consume foods in that category to continue without being presented with long lists of irrelevant choices. The majority of questions required radio button responses, which by design only permitted a single selection.

Surveys were designed to be a straightforward exercise, with each food question indicating recommended serving size (National Health and Medical Research Council, 2013). Each food frequency survey offered participants an option to declare additional foods by free text. All responses were categorical, with respondents asked how often in the last month they had eaten each food. Participants were given the option of six food frequencies; each of these responses was allocated a numerical value, facilitating calculation of the average equivalent serves consumed by the respondent per day. The two exceptions to this were the food groups with higher upper limits of daily recommendations (2–3 per day, 4–5 per day, and 6+ per day). Responses were mandatory for each of the specific food frequency questions, and as such, respondents were unable to submit a survey with unanswered fields.

Twelve core surveys were created. Each survey was presented, completed, and submitted as an independent activity. In this manner, data were complete for each submitted survey, and women who did not complete the full set of surveys continued to contribute meaningful data pertaining to specific behaviours. Collectively, the series of surveys investigated demographics, health status, reproductive stage, drug, alcohol, and supplement use as well as dietary decision-making and food frequency in respondents.

2.2.1 | Demographics and lifestyle

Surveys 1 to 3 sought information relating to demographics, reproductive status, obstetric history, general health, and lifestyle factors

(Table 1). Questions regarding obstetric history varied depending on whether the participant declared herself to be pregnant, planning, or nonpregnant. The health-related survey collected basic physical health parameters enabling calculation of body mass index and gestational weight gain. Blood pressure and diabetes questions were designed to measure respondent's awareness of their status with regard to that variable as much as record physical measurements and management strategies. The medications, drugs, and alcohol survey presented the participant with a dichotomous yes/no declaration of engagement with a particular activity. Further questions were presented subsequent to affirmative responses. Motives underlying food selection were also investigated, providing a list of 24 options from which the respondent could select multiple responses (Table 1).

Supplement use was investigated from a number of perspectives. Initially, respondents were surveyed regarding their use and frequency of multivitamin supplements. For those declaring multivitamin use, brand specification and frequency was requested. Individual supplement use was an opt-in question. A list of 22 supplements was presented to those responding in the affirmative (Table 2). Participants were required to indicate frequency of use for all listed supplements to ensure a clean and complete response. The timing of supplementation in relation to pregnancy state and declaration of iron infusions or injections were a requirement. Additionally, women were asked to declare their single greatest influence on supplement use from a defined list of alternatives (Table 2).

2.2.2 | Food frequency questionnaires

The food frequency surveys were divided into seven individual food types—protein, carbohydrates, fruit and vegetables, dairy, fluids, takeaway and junk food and incidentals such as spreads, fats, oils, sauces, and dressings (Table 3). These foods were represented in their most basic and recognisable form, allowing for deconstruction of meals to their fundamental elements irrespective of cooking method or combination. Serving sizes were detailed with each option (National Health and Medical Research Council, 2015). No foods were included that were unique to the Australian context. The questionnaire accounted for 150 primary foods, with nine subcategories presenting a further 85 selections. In addition to frequency of consumption, surveys were designed to extract information pertaining to adherence to recommendations regarding food avoidance during pregnancy, for example, smallgoods, soft cheeses, and caffeine.

2.3 | Development

The development of the MONT was concurrent with the website. Surveys were originally mapped in a word document and then transferred to the digital format using high-quality images licenced for digital reproduction. WordPress was selected as the most suitable platform on which to develop the tool due to its flexibility, ease of use, and cost-effectiveness. The use of WordPress facilitated both website and tool creation by the researcher, minimising associated development costs. WordPress compatible plugins were utilised for

TABLE 1 Demographic and lifestyle surveys content

About me (Not pregnant, not planning)	About me (Planning or trying)	About me (Pregnant)
<ul style="list-style-type: none"> • Age • Completed education level • Annual income • Ethnicity • Country of birth • Parity • Gestation at last birth • Previous pregnancy complications • Conception <ul style="list-style-type: none"> • Natural • Assisted reproductive technology • Family planning factors 	<ul style="list-style-type: none"> • Age • Completed education level • Annual income • Ethnicity • Country of birth • Parity • Gestation at last birth • Previous pregnancy complications • Conception <ul style="list-style-type: none"> • Natural • Assisted reproductive technology • Planning or trying • Length of trying • Conception method <ul style="list-style-type: none"> • Natural • Assisted reproductive technology 	<ul style="list-style-type: none"> • Age • Completed education level • Annual income • Ethnicity • Country of birth • Parity • Gestation at last birth • Previous pregnancy complications • Conception <ul style="list-style-type: none"> • Natural • Assisted reproductive technology • Planned or unplanned • EDD • Date and method of calculation • Current gestation
My health	Medications, drugs and, alcohol	Why I eat what I eat
<ul style="list-style-type: none"> • Weight • Current • Pre-pregnancy (if applicable) • Height • Blood pressure <ul style="list-style-type: none"> • Status (i.e., normotensive and hypertensive) • Last measurement • Medication • Diabetes <ul style="list-style-type: none"> • Status • Type • Method of management • Latest reading • Other 	<ul style="list-style-type: none"> • Smoking (frequency if applicable) • Alcohol consumption <ul style="list-style-type: none"> • Beer • Wine • Spirits • Frequency • Prescription drugs <ul style="list-style-type: none"> • Antidepressants • Anti-anxiety • ADHD medication • Anti-epileptics • Opioids • Benzodiazepines • Recreational drug use <ul style="list-style-type: none"> • Marijuana <ul style="list-style-type: none"> • Frequency • Mode of use • Amphetamines • Cocaine • Ecstasy • Ice 	<ul style="list-style-type: none"> • Protein and complex carbohydrate consumption influences • Determinants of food choice <ul style="list-style-type: none"> • Cultural/ethnic beliefs • Ease of preparation • My friends/family eat it • Preservative content • Calorie content • Fat content • Fibre content • My budget • Value for money • It is familiar • It is easily available • Gives me energy • Smells good • Tastes good • Texture • Comfort food • Childhood memories • Nutritious • Looks good • It is good for me • Habit

TABLE 2 Supplement use

General supplements	Individual micronutrients	Influences
<ul style="list-style-type: none"> • Multivitamins (use, brand) • Oils (fish, flaxseed, evening primrose) • Raspberry leaf • Probiotics • Sustagen • Protein powder 	<ul style="list-style-type: none"> • Folic acid • Iron • Iodine • Zinc • Calcium • Selenium • Potassium • Magnesium 	<ul style="list-style-type: none"> • Family • Friends • Doctor • Nurse • Midwife • Media • Naturopath • Other

TABLE 3 Food frequency questionnaire content

Meat and other protein	Breads	Other carbohydrates	Fruit	Vegetables	Dairy products
<ul style="list-style-type: none"> • Beef • Sheep • Pork • Ham/bacon • Smallgoods • Chicken <ul style="list-style-type: none"> • Skin • No skin • Turkey • Game • Fish <ul style="list-style-type: none"> • White • Oily • Fish canned, in <ul style="list-style-type: none"> • Oil • Brine • Water • Shellfish • Crustaceans • Egg • Tofu • Legumes • Nuts 	<ul style="list-style-type: none"> • Bread <ul style="list-style-type: none"> • White • Wholemeal • Multigrain • Dark rye • Light rye • Fruit • Flat • Bread roll <ul style="list-style-type: none"> • White • Wholemeal • Multigrain • English muffin <ul style="list-style-type: none"> • Plain • Fruit 	<ul style="list-style-type: none"> • Crispbreads <ul style="list-style-type: none"> • Noodles • Wheat <ul style="list-style-type: none"> • Instant • Rice • Pasta • Couscous • Polenta • Rice <ul style="list-style-type: none"> • White • Brown • Wild • Weetbix • Cornflakes • Rice bubbles • Muesli, Porridge 	<ul style="list-style-type: none"> • Fresh <ul style="list-style-type: none"> • Apples or pears • Citrus • Grapes • Bananas • Avocado • Berries • Stone fruit • Melon • Kiwifruit • Olives • Dried/canned in juice/syrup <ul style="list-style-type: none"> • Apples or pears • Prunes • Dates • Cranberries • Sultanas/raisins • Bananas • Goji • Peaches • Apricots • Fruit salad • Two fruits 	<ul style="list-style-type: none"> • Potatoes • Sweet potatoes • Pumpkin • Tomatoes • Broccoli • Carrots • Corn • Capsicum • Kale/cooked greens • Spinach • Cabbage • Cauliflower • Peas/green beans, eggplant/zucchini/squash • Cucumber • Celery • Lettuce • Onions/garlic 	<ul style="list-style-type: none"> • Milk <ul style="list-style-type: none"> • Whole • Reduced fat • Skim • Soy • Cheese <ul style="list-style-type: none"> • Curd • Cream • Soft • Hard • Cream <ul style="list-style-type: none"> • Full fat • Low fat • Custard • Plain yoghurt <ul style="list-style-type: none"> • Full fat • Low fat • Fruit yoghurt <ul style="list-style-type: none"> • Full fat • Low fat • Frozen yoghurt <ul style="list-style-type: none"> • Full fat • Low fat • Ice cream <ul style="list-style-type: none"> • Full fat • Low fat
Hot and cold drinks	Takeaway	Takeaway cont.	Junk food	Spreads, fats, and oils	Sauces and dressings
<ul style="list-style-type: none"> • Still water <ul style="list-style-type: none"> • Tap • Bottled • 35% juice drink • 100% juice <ul style="list-style-type: none"> • Orange or other citrus • Apple • Tomato • Vegetable • Prune • Fresh squeezed juice <ul style="list-style-type: none"> • Citrus • Apple • Vegetable • Soda water <ul style="list-style-type: none"> • Plain • Flavoured • Mineral water <ul style="list-style-type: none"> • Plain • Flavoured • Soft drink (± sugar and/or caffeine) • Sports drinks • Energy drinks 	<ul style="list-style-type: none"> McDonalds <ul style="list-style-type: none"> • Burger <ul style="list-style-type: none"> • Beef • Chicken • Fish • Wrap • Nuggets • Fries • Salads • Hotcakes • Hash browns • McMuffin • Brekky wrap • Soft drink • Dessert Hungry Jacks <ul style="list-style-type: none"> • Burger <ul style="list-style-type: none"> • Beef • Chicken • Nuggets • Fries • Soft drink • Dessert 	<ul style="list-style-type: none"> Kentucky Fried Chicken <ul style="list-style-type: none"> • Chicken burger • Twister • Chicken pieces • Nuggets • Popcorn chicken • Chicken salad • Fries • Potato and gravy • Coleslaw • Soft drink • Dessert Pizza <ul style="list-style-type: none"> • Home-made • Frozen • Store made 	<ul style="list-style-type: none"> • Potato chips • Biscuits <ul style="list-style-type: none"> • Sweet • Savoury • Cakes • Muffins • Desserts • Chocolate • Lollies • Muesli bars • Fruit and nut bars 	<ul style="list-style-type: none"> • Peanut butter • Vegemite • Jam • Honey • Butter • Butter blend <ul style="list-style-type: none"> • Regular • Light • Margarine <ul style="list-style-type: none"> • Regular • Light • Oil <ul style="list-style-type: none"> • Olive • Vegetable • Canola • Peanut • Animal fat (lard) • Ghee 	<ul style="list-style-type: none"> • Tomato/BBQ Sauce • Mayo <ul style="list-style-type: none"> • Regular • Light • Salad dressing <ul style="list-style-type: none"> • Regular • Low fat • Vinaigrette • Apple sauce • Cranberry sauce • Mustard • Salsa • Salt • Sugar

participant management, survey design, and reporting, ensuring ease of access and download for data. Responsive website design was a required feature of this project as access to both the website, and

MONT was necessary on a variety of devices, including desktop and laptop computer and hand-held devices such as tablets and smartphones.

2.4 | Evaluation

Survey data were downloaded from the website database in .csv format and transferred to SPSS version 20. Descriptive statistics were used to characterise the cohort in terms of demographic and reproductive profiles, engagement, completions, and costing.

2.5 | Ethics

This research was undertaken with the approval of the Gold Coast Health and Hospital Service Human Research Ethics Committee (HREC 16/QGC/70), dated April 7, 2016.

3 | RESULTS

3.1 | Cohort characteristics

Characteristics of the cohort were assessed in terms of age group, reproductive status, engagement, dataset completion, country, ethnicity, education level, annual income, and referral source. Results are reported in Table 4. Ubiquitous access to the website resulted in recruitment from 13 countries. Women of seven ethnicities were

TABLE 4 Cohort characteristics

	Trial phase (n = 187) (24/05/ 16–30/09/17)		Overall pilot (n = 502) (24/05/ 16–30/09/17)	
	n	%	n	%
Age group (n)	102		331	
15–24	23	22.5	85	25.7
25–34	58	56.9	191	57.7
35–44	21	20.6	55	16.6
Engagement (n)	187		502	
None	73	39.0	161	32.2
Survey submissions	114	61.0	341	67.8
Partial	83	72.8	227	66.5
Complete	31	27.2	114	33.5
Reproductive group (n)	102		502	
Pregnant	57	55.9	376	75.0
Planning	14	13.7	31	6.1
Not pregnant	31	30.4	95	18.9
Education (n)	107		331	
No high school	0	0.0	2	0.6
8–11	8	7.5	34	10.3
Finished high school	24	22.4	73	22.1
TAFE/trade or apprenticeship	19	17.8	69	20.8
University degree	56	53.3	153	46.2
Annual income (n)	107		331	
<30 K	9	8.4	43	13.0
30–50 K	11	10.3	41	12.4
50–70 K	19	17.8	68	20.5
70–90 K	17	15.9	49	14.8
90–120 K	25	23.4	65	19.6

(Continues)

TABLE 4 (Continued)

	Trial phase (n = 187) (24/05/ 16–30/09/17)		Overall pilot (n = 502) (24/05/ 16–30/09/17)	
	n	%	n	%
120–150 K	15	14.0	41	12.4
>150 K	11	10.3	24	7.3
Country of access (n)	171		502	
Australia	158	92.4	481	95.8
Canada	1	0.6	1	0.2
UK	1	0.6	1	0.2
Vietnam	1	0.6	1	0.2
India	3	1.7	8	1.6
Africa/South Africa	1	0.6	1	0.2
New Zealand	1	0.6	2	0.4
Indonesia	1	0.6	1	0.2
Sweden	1	0.6	1	0.2
United States	3	1.7	5	0.1
Ethnicity (n)	102		331	
Caucasian	92	90.2	278	84.0
Australian Aboriginal	2	2.0	9	2.7
Torres Strait islander	0	0	0	0
Maori/Pacific islander	0	0	9	2.7
Papua New Guinea/Timorese	0	0	1	0.3
Mediterranean	1	1.0	4	1.2
Indian/Pakistani/Bangladeshi	1	1.0	7	2.1
Cambodian/Vietnamese/Thai	0	0	1	0.3
Malay/Filipino/Indonesian	1	1.0	4	1.2
Chinese/Korean/Japanese	2	2.0	7	2.1
Middle Eastern	0	0	1	0.3
African	2	2.0	4	1.2
Central/South American	0	0	4	1.2
Other/mixed	0	0	2	0.6
Referral (n)	187		502	
Midwife	45	24.1	168	33.5
Hospital advertising	36	19.3	159	31.6
Social media/internet/media	21	11.2	59	11.7
Other	31	16.5	62	12.4
Not stated	54	28.9	54	10.8

identified as existing within data declared during the trial phase; this increased to 13 ethnicities and 20 countries of birth across the entire pilot. A total of 458 women were passively recruited; a further 44 recruited during the initial active recruiting phase (n = 502). The majority of recruits identified themselves as pregnant (n = 376, 74.9%). This majority is reflected in the statistics relating to source of referral, with 61% of women quoting antenatal clinic resources as being responsible for their awareness of the project.

Women aged 25–34 comprised 57.7% of the cohort, a figure that remained consistent across both phases and recruitment methods (54.8–58.3%). Nulliparous women accounted for 63% of overall recruits with multiparous women the remaining 37%. These results were more evenly distributed within the actively recruited group (47.5% nulliparous vs. 52.5% multiparous).

Education level and annual income were available for 331 participants. Although both demonstrated normal distribution, annual income was more evenly distributed across categories than education level with the \$50,000–\$70,000 annual income group the most frequently selected ($n = 68$, 20.5%). The majority of respondents reported a tertiary level education ($n = 153$, 46.2%). Actively recruited women returned a different distribution with regard to education with completion of secondary and tertiary education being the most commonly declared (Table 5).

3.2 | Completions

Of those recruited, 341 women commenced the survey set, thereby contributing to the data (68%). A total of 2,448 individual surveys were submitted during the pilot study; 114 out of the 341 participants submitted complete datasets (33.5%). Further analysis of completion rates between passive and active recruits demonstrated that survey

TABLE 5 Passive versus active recruitment

	Passive recruitment ($n = 458$) (24/05/ 2016–30/09/17)		Active recruitment ($n = 44$) (05/09/ 17–30/09/17)	
	<i>n</i>	%	<i>n</i>	%
Age group (<i>n</i>)	290		42	
15–24	74	25.5	11	26.2
25–34	169	58.3	23	54.8
35–44	47	16.2	8	19.0
Engagement (<i>n</i>)	458		44	
None	161	35.2	1	2.3
Survey submissions	297	64.8	43	97.7
Partial	214	72.1	12	27.9
Complete	83	27.9	31	72.1
Education (<i>n</i>)	289		42	
No high school	1	0.3	1	2.4
8–11	29	10.0	5	11.9
Finished high school	58	20.0	15	35.7
TAFE/trade or apprenticeship	64	22.1	5	11.9
University degree	137	47.4	16	38.0
Annual income (<i>n</i>)	289		42	
<30 K	35	12.1	8	19.0
30–50 K	38	13.1	3	7.1
50–70 K	57	19.7	11	26.2
70–90 K	41	14.2	8	19.0
90–120 K	64	22.1	1	2.4
120–150 K	34	11.8	7	16.7
>150 K	20	6.9	4	9.5
Country of birth (<i>n</i>)	290		41	
Australia	207	71.4	24	58.5
Canada	3	1.0	0	0
UK	21	7.2	1	2.4
India	4	1.4	0	0
Sudan	0	0	1	2.4
Tanzania	1	0.3	1	2.4

(Continues)

TABLE 5 (Continued)

	Passive recruitment ($n = 458$) (24/05/ 2016–30/09/17)		Active recruitment ($n = 44$) (05/09/ 17–30/09/17)	
	<i>n</i>	%	<i>n</i>	%
New Zealand	23	7.9	6	14.6
Indonesia	1	0.3	0	0
Sweden	0	0	0	0
United States	7	2.4	0	0
South Africa	6	2.1	1	2.4
South Korea	0	0	1	2.4
Philippines	0	0	1	2.4
Papua New Guinea	0	0	1	2.4
Japan	0	0	3	7.3
China	0	0	1	2.4
Bosnia	3	1.0	0	0
Brazil	2	0.7	0	0
Chile	1	0.3	0	0
Hong Kong	4	1.4	0	0
Hungary	1	0.3	0	0
Italy	1	0.3	0	0
Kenya	1	0.3	0	0
Nepal	1	0.3	0	0
Singapore	1	0.3	0	0
Slovakia	1	0.3	0	0
Zimbabwe	1	0.3	0	0
Ethnicity (<i>n</i>)	290		41	
Caucasian	253	87.2	26	63.4
Australian Aboriginal	6	2.1	3	7.3
Torres Strait islander	0	0	0	0
Maori/Pacific islander	7	2.4	2	4.9
Papua New Guinea/Timorese	0	0	1	2.4
Mediterranean	3	1.0	1	2.4
Indian/Pakistani/Bangladeshi	7	2.4	0	0
Cambodian/Vietnamese/Thai	1	0.3	0	0
Malay/Filipino/Indonesian	2	0.7	1	2.4
Chinese/Korean/Japanese	2	0.7	5	12.2
Middle Eastern	0	0	1	2.4
African	3	1.0	1	2.4
Central/South American	4	1.4	0	0
Other	2	0.7	0	0

sets were complete in 27.9% and incomplete in 72.1% of passive recruits; these figures were reversed in the active recruit subset (Table 5).

3.3 | Resource management

The total financial cost of design, development, and promotion of the MONT pilot study are reported in Table 6. A proportion of the initial costs are attributable to intermittent or one-off marketing trials, digital security, and purchase of themes and add-ons for the website. In the period from September 30, 2016, and September 30, 2017,

TABLE 6 Resource management

	Trial phase (<i>n</i> = 187) (24/05/ 16–30/09/17)	First year (<i>n</i> = 315) (01/ 10/16–30/09 /17)	Overall (<i>n</i> = 502) (24/ 05/16–30/09 /17)
Total individual surveys	760	1,688	2,448
Total financial cost	\$1,869.60	\$468.35	\$2,337.95
Cost per survey— recruitment/ distribution	\$2.46	\$0.28	\$0.96
Total completions	31	83	114
Cost per completion	\$60.31	\$5.64	\$20.51
Total analysis time	16 hr		8 hr
Analysis time per survey	1 m 26 s		12 s
Analysis time per completion	30 min		4 m 21 s

maintenance and recruitment costs totalled \$468.35, equating to \$5.64 per completion, or \$0.28 per survey (Table 6).

Data handling time for the 760 individual pilot study submissions across 36 surveys (12 per group for each reproductive subset) was 16 hr, including data download and export, coding, codebook development, analysis, and transfer to tables. Data were clean with no significant aberrant data submitted. This equates to a data handling time of 1 min 26 s per survey. A further 8 hr was invested in the additional examination and comparison of data and performance over the first year. Total processing and analysis time for the pilot dataset equated to 12 s per survey (Table 6).

4 | DISCUSSION

The MONT was used successfully by women from a variety of continents and cultures. Lack of statistical significance between completion times in actively recruited women with English as a first and a second language suggest that the design of the MONT has addressed completion issues faced by CALD women in previous studies (Tripp et al., 2014). However active recruitment offered all eligible participants engagement irrespective of cultural or linguistic background and resulted in both lower Caucasian majority and wider cohort diversity than the passively recruited group. This supports the premise that women of CALD are less likely to self-select participation in research of this nature (Rodger et al., 2013). This reflects a degree of self-marginalisation from within the CALD community. However, the distribution of annual income reported by respondents did not support previous research regarding the lack of engagement previously demonstrated by low socio-economic groups (Rodger et al., 2013).

Demographic analysis of the cohort demonstrated that first-time mothers constituted approximately two thirds of passively recruited participants, concurring with previous research describing the enhanced information seeking behaviours of nulliparous women (Szwajcer, Woerkum, Koelen, & Hiddink, 2005). This is supported by

the relatively even distribution of women with and without children in the actively recruited subset.

Performance of the MONT in comparison with similar tools and contrasting methodologies has been confounded by the novel nature of the tool. Although literature suggests that the food frequency questionnaire is an inexpensive option for the collection of nutrition-related information (Subar et al., 2001), no published data has been found detailing the resources required for development, distribution, processing, and analysis of such tools on a per survey basis. The MONT proved to be practical and economical in terms of resource management, with the pilot completed well within low budgetary confines and human resources. Data processing efficiency was enhanced by the clean dataset. Maintenance costs are low and decreasing on a per survey basis as numbers increase.

Assessing the MONT in terms of response and completion rates has also proven difficult given the unique methodology utilised and lack of comparable data for passive recruitment strategies. This statistical gap originates from user differences; those accessing foundation food frequency questionnaires in the online environment are essentially actively recruited and are therefore inappropriate for use as a comparative population. Further, accurate definition of the target population was not possible given the website was available and promoted worldwide. Although this strategy resulted in universal access and broad multicultural exposure, the potential recruit population was uncontrolled resulting in an inability to differentiate between reach, out-of-scope participants, recruit attrition, and refusals.

As such traditional calculation of participation and completion rates was not possible; participation rates were derived from known registrants and their subsequent level of engagement. Completions were calculated from those who submitted surveys. As passive recruits were merely exposed to the promotional material and participation was entirely of their choosing, response and completion rates for electronic survey distribution methods such as email were not considered a comparable baseline. Comparison of the response and completion rates with similar survey formats was not possible due to lack of published data for online food frequency questionnaires. Completion rates were markedly improved when respondents were actively recruited by a researcher or HCW. Maternal and infant health is an area where global digital data collection would be of great benefit, regardless of whether data are self-reported or collected by HCWs. The development, validation, and implementation of cross-cultural, digital data collection tools may therefore assist us to distinguish constants from variables and assess their influence on reproductive outcomes. As such the incorporation of digital recruitment and data collection into modern research methodology may signal the paradigm shift that medical research requires to meet international recommendations.

5 | CONCLUSION

The tool was used successfully by women from a variety of continents and cultures and proved to be practical and economical in terms of resource management. This paper is the first of three detailing the findings of the MONT pilot study and has provided a foundation for

further investigations into nutrition-related decision-making and data collection in pregnant women of the Gold Coast, Australia.

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CONFLICTS OF INTEREST

None of the authors have any competing interests, nor are there any issues raised by the editorial policies that require further clarification.

CONTRIBUTIONS

This paper is the original work of the authors. JM proposed, developed, collected data, and authored the paper; JV and AP critically reviewed and approved the manuscript for final submission and publication. It is not under consideration elsewhere and has not been previously published.

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REFERENCES

- Barbieri, P., Nishimura, R. Y., Crivellenti, L. C., & Sartorelli, D. S. (2013). Relative validation of a quantitative FFQ for use in Brazilian pregnant women. *Public Health Nutrition*, 16(8), 1419–1426. <https://doi.org/10.1017/S1368980012003783>
- Boucher, B., Cotterchio, M., Kreiger, N., Nadalin, V., Block, T., & Block, G. (2006). Validity and reliability of the Block98 food-frequency questionnaire in a sample of Canadian women. *Public Health Nutrition*, 9(1), 84–93.
- Brantsæter, A. L., Haugen, M., Alexander, J., & Meltzer, H. M. (2008). Validity of a new food frequency questionnaire for pregnant women in the Norwegian Mother and Child Cohort Study (MoBa). *Maternal & Child Nutrition*, 4(1), 28–43. <https://doi.org/10.1111/j.1740-8709.2007.00103.x>
- Brantsæter, A. L., Haugen, M., Hagve, T.-A., Aksnes, L., Rasmussen, S. E., Julshamn, K., ... Meltzer, H. M. (2007). Self-reported dietary supplement use is confirmed by biological markers in the Norwegian Mother and Child Cohort Study (MoBa). *Annals of Nutrition and Metabolism*, 51(2), 146–154. <https://doi.org/10.1159/000103275>
- Chappell, L. C., Seed, P. T., Myers, J., Taylor, R. S., Kenny, L. C., Dekker, G. A., ... Poston, L. (2013). Exploration and confirmation of factors associated with uncomplicated pregnancy in nulliparous women: Prospective cohort study. *BMJ (Clinical research ed.)*, 347, f6398.
- Detours, V., Dumont, J. E., Bersini, H., & Maenhaut, C. (2003). *Integration and cross-validation of high-throughput gene expression data: Comparing heterogeneous data sets* (Vol. 546). (pp. 98–102). Netherlands: Elsevier B.V.
- Dwarkanath, P., Soares, M. J., Thomas, T., Vaz, M., Swaminathan, S., & Kurpad, A. V. (2014). Food frequency questionnaire is a valid tool for the assessment of dietary habits of South Indian pregnant women. *Asia-Pacific Journal of Public Health/Asia-Pacific Academic Consortium for Public Health*, 26(5), 494–506. <https://doi.org/10.1177/1010539512459945>
- Fee, S. B., & Griffith, C. (2013). Custom mobile applications for collection of field data. *Council on Undergraduate Research Quarterly*, 34(2), 22.
- Higginbottom, G. M., Vallianatos, H., Forgeron, J., Gibbons, D., Malhi, R., & Mamede, F. (2011). Food choices and practices during pregnancy of immigrant and aboriginal women in Canada: A study protocol. *BMC Pregnancy and Childbirth*, 11(1), 100–100. <https://doi.org/10.1186/1471-2393-11-100>
- Hovdenak, N., & Haram, K. (2012). Influence of mineral and vitamin supplements on pregnancy outcome. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*, 164(2), 127–132. <https://doi.org/10.1016/j.ejogrb.2012.06.020>
- International Food Policy Research Institute. (2014). Global nutrition report 2014: Actions and accountability to accelerate the world's progress on nutrition. Retrieved from Washington, DC.
- Mouratidou, T., Ford, F., & Fraser, R. B. (2006). Validation of a food-frequency questionnaire for use in pregnancy. *Public Health Nutrition*, 9(4), 515–522. <https://doi.org/10.1079/PHN2005876>
- National Health and Medical Research Council (2013). *Australian dietary guidelines*. Canberra: National Health and Medical Research Council.
- National Health and Medical Research Council. (2015). Serve sizes. Retrieved from <https://www.eatforhealth.gov.au/food-essentials/how-much-do-we-need-each-day/serve-sizes>
- Rodger, D., Skuse, A., Wilmore, M., Humphreys, S., Dalton, J., Flabouris, M., & Clifton, V. L. (2013). Pregnant women's use of information and communications technologies to access pregnancy-related health information in South Australia. *Australian Journal of Primary Health*, 19(4), 308–312.
- Scales, N., Krogstrand, K. S., Albrecht, J., & Eskridge, K. (2013). Reliability and validity of a culturally appropriate food frequency questionnaire to measure omega-3 fatty acid intakes in Midwestern African American women of childbearing age. *Journal of the Academy of Nutrition and Dietetics*, 113(9), A_22
- Stephoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: The Food Choice Questionnaire. *Appetite*, 25(3), 267–284. <https://doi.org/10.1006/appe.1995.0061>
- Subar, A. F., Thompson, F. E., Kipnis, V., Midthune, D., Hurwitz, P., McNutt, S., ... Rosenfeld, S. (2001). Comparative validation of the Block, Willett, and National Cancer Institute food frequency questionnaires: The Eating at America's Table Study. *American Journal of Epidemiology*, 154(12), 1089–1099. <https://doi.org/10.1093/aje/154.12.1089>
- Szwajcer, E. M., Woerkum, v. C. M. J., Koelen, M. A., & Hiddink, G. J. (2005). Nutrition-related information seeking behaviours before and throughout the course of pregnancy: Consequences for nutrition communication. *European Journal of Clinical Nutrition*, 59(suppl. 1), S57–S65. <https://doi.org/10.1038/sj.ejcn.1602175>
- Tomlinson, M., Solomon, W., Singh, Y., Doherty, T., Chopra, M., Ijumba, P., ... Jackson, D. (2009). The use of mobile phones as a data collection tool: A report from a household survey in South Africa. *BMC Medical Informatics and Decision Making*, 9(1), 51–51. <https://doi.org/10.1186/1472-6947-9-51>
- Tripp, N., Hainey, K., Liu, A., Poulton, A., Peek, M., Kim, J., & Nanan, R. (2014). An emerging model of maternity care: Smartphone, midwife, doctor? *Women and birth: journal of the Australian College of Midwives*, 27(1), 64–67.
- United Nations. (2015). The Millennium Development Goals report. Retrieved from New York: [http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20\(July%201\).pdf](http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf)
- United Nations. (2016). The sustainable development agenda Retrieved from <http://www.un.org/sustainabledevelopment/development-agenda/#>
- van Velthoven, M. H., Car, J., Zhang, Y., & Marušić, A. (2013). mHealth series: New ideas for mHealth data collection implementation in low- and middle-income countries. *Journal of global health*, 3(2), 020101.
- Wheeler, A. J., Feetam, C. L., & Harrison, J. (2014). Pathway to clozapine use: A comparison between a patient cohort from New Zealand and a cohort from the United Kingdom. *Clinical Drug Investigation*, 34(3), 203–211. <https://doi.org/10.1007/s40261-013-0166-x>

- Willett, W. C., Sampson, L., Stampfer, M. J., Rosner, B., Bain, C., Witschi, J., ... Speizer, F. E. (1985). Reproducibility and validity of a semiquantitative food frequency questionnaire. *American Journal of Epidemiology*, 122(1), 51–65.
- Zhang, S., Wu, Q., van Velthoven, M. H., Chen, L., Car, J., Rudan, I., ... Scherpbier, R. W. (2012). Smartphone versus pen-and-paper data collection of infant feeding practices in rural China. *Journal of Medical Internet Research*, 14(5), e119.

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