Smart Food: Crowdsourcing of experts in nutrition and non-experts in identifying calories of meals using smartphone as a potential tool contributing to obesity prevention and management

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Abstract—To address an increasing global health problem of obesity, further innovative initiatives are required. One such initiative is personalized messaging using mobile applications as a potential tool contributing to obesity prevention and management. In order to achieve this, there are challenges that need to be considered first including the accurate estimation of calories of meals and individuals’ calorific intakes using a smartphones. There is also a lack of evidence indicating whether novices, peers and family members can provide accurate tailored feedback on calorie intake and nutrition. The two study objectives were i. To determine the feasibility of experts in nutrition and non-experts accurately identifying calories of meals from photographs as taken on a smartphone; and ii. To inform the development a personalized messaging system for obesity prevention and management using a mobile application. This study was an experimental design using a quantitative online survey with 24 participants, consisting of 12 experts in nutrition and/or dietetics, and 12 non-experts. The non-expert group attended a training session and both groups completed an online survey. The survey consisted of 15 meals, the participants were required to view the photographs and then answer the following question for each photograph: “From viewing the above photograph, enter the number of calories you consider is in this meal? _______Kcal OR _______KJ”. Crowdsourcing was used. The results revealed that the percentage difference between the estimated calories count in the meals against the actual number of calories was on average +55% (SD 79.9) for the non-expert group and +8% (SD 15.1) for the expert group (t-test, P<0.001). When using crowdsourcing, aggregating opinions from experts and also non-experts improves accuracy. The mode estimate from a crowd of experts is more accurate than 79% of individual experts. The crowd of non-experts’ average median difference out performed 63% of individual non-experts. Thus the crowd of non-experts is more accurate in estimating calories from photographs taken on a smartphone than most individuals. When designing a personalized messaging system for obesity prevention and management using a mobile application, a crowd of experts in nutrition and also a crowd of non-experts should be included to estimate calories in foods from photographs taken on a smartphone. This may have potential in contributing to obesity prevention and management, which warrant further research.

Keywords—smartphones, crowdsourcing, obesity, nutrition

I. INTRODUCTION

Obesity is a global public health issue that needs to be further addressed [1]. There is some evidence that personalized messaging using mobile applications such as computerized tailored text messaging has potential for obesity prevention and management [2]. However, at present there is limited research evidence in personalized messaging using mobile applications for obesity prevention and management. One of the main challenges is the accurate estimation of
calories of meals and individuals’ calorific intakes. There is also a lack of evidence indicating whether novices, peers and family members can provide accurate tailored feedback on calorie intake and nutrition. Crowdsourcing research allows investigators to engage with a lot of people to provide either data or data analysis [3]. A recent review concluded that utilizing crowdsourcing can improve the quality, cost, and speed of a research project while engaging large segments of the public and creating novel science [3]. Crowdsourcing has been reported with increasing potential in obesity research [4-6]. Thus it is important to determine if crowdsourcing of experts in nutrition and non-experts can accurately identify calories in meals from digital photographs taken on a smartphone, and whether it can be used to develop a personalized messaging system for obesity prevention and management using a mobile application.

II. OBJECTIVES

The two objectives were i. To determine the feasibility of experts in nutrition and non-experts accurately identifying calories of meals from photographs as taken on a smartphone; and ii. To inform the development a personalized messaging system for obesity prevention and management using a mobile application.

III. METHODS

This study was an experimental design using a quantitative online survey with 24 participants, consisting of 12 experts in nutrition and/or dietetics, and 12 non-experts. The inclusion criteria for the experts were: adults aged 18-65 years; self-reported heathy, and registered Dietitian or Nutritionist. For the non-experts, the inclusion criteria were adults aged 18-65 years, and self-reported heathy. The exclusion criteria for both experts and non-experts were not willing to participate, and not consenting. The expert group had a mean age of 37 years with an average of 12 years of experience in nutrition/dietetics (range 3-30 years), while the mean age of the non-expert group was 27 years.

For the non-expert group, participants attended a session, where a Registered Nutritionist (AM) gave training on estimating calories (20 mins; short training). The training session consisted of: introductions, consent, training and online survey. The content of the training component included: calories; body weight; balanced Diet (Eatwell plate), portion sizes, food tables, calories in foods, and numerous examples of calories in most common food. Immediately following the training, the participants completed an online survey. This online survey consisted of three sections, 1. demographics of the participants (e.g. gender, age); 2. photographs; and 3. confidence levels (e.g. how confident were you estimating the calories from the photographs?). The photograph section consisted of 15 photographs of meals, which consisted of five breakfasts, five lunches, and five dinners. For each of the 15 meals, the participants were required to view the photographs and then answer the following question: “From viewing the above photograph, enter the number of calories you consider is in this meal? ___________Kcal OR ___________KJ”. The expert group did not receive training but completed the online survey. One month later, both the expert and non-expert groups completed the same online survey for the second time.

In this study, 720 estimates were collected, with 360 from non-experts (15 photographs * 12 non-experts * 2 time instances=360) and also 360 estimates from experts (15 photographs * 12 experts * 2 time instances=360). For this study, two time instances (immediately after training for the non-experts or time 1 for the experts, and 1 month later for both groups) to represent any natural intra-rater variability from experts and non-experts in the dataset.

The theoretical hypothesis of crowdsourcing is that opinions from a crowd of experts or non-experts can be aggregated to provide collective wisdom. Moreover it is also theorized that such aggregation provides greater veracity when compared to individual leading experts in the respective field. Data was analyzed using SPSS version 21. Ethical approval was granted from University of Ulster for this study.

IV. RESULTS

Findings revealed that the percentage difference between the estimated calories count in the meals against the actual number of calories was on average +55% (SD 79.9) for the non-expert group and +8% (SD 15.1) for the expert group (t-test, P<0.001). Overall, there were no significant differences between the first and second surveys for both the expert and non-expert groups. Some individuals were significantly (t-test, P<0.05) more accurate in estimating calories both in the expert and non-expert groups.

When using crowdsourcing, the crowd of experts was more accurate when compared to the crowd of non-experts who had a short training session in identifying calories of

| 15 photographs of meals taken on a smartphone (calories, Kcal) | Breakfast 1 | Breakfast 2 | Breakfast 3 | Breakfast 4 | Breakfast 5 | Lunch 1 | Lunch 2 | Lunch 3 | Lunch 4 | Lunch 5 | Dinner 1 | Dinner 2 | Dinner 3 | Dinner 4 | Dinner 5 |
|---------------------------------------------------------------|-------------|-------------|-------------|-------------|-------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| **Accurate calories**                                         | 172         | 700         | 271         | 160         | 80          | 400    | 315    | 295    | 495    | 410    | 634    | 400    | 349    | 341    | 577    |
| **Everyone mode**                                             | 500         | 700         | 250         | 180         | 89          | 400    | 360    | 349    | 595    | 439    | 600    | 360    | 349    | 432    |
| **Everyone mean**                                             | 227         | 725         | 318         | 254         | 96          | 426    | 413    | 410    | 880    | 705    | 373    | 350    | 550    | 575    |
| **Experts mode**                                              | 170         | 700         | 270         | 180         | 89          | 400    | 320    | 300    | 500    | 450    | 600    | 400    | 350    | 550    | 575    |
| **Experts mean**                                              | 203         | 732         | 271         | 100         | 81          | 491    | 373    | 309    | 549    | 520    | 693    | 432    | 521    | 539    | 606    |
| **Non-experts mode**                                          | 250         | 1000        | 400         | 250         | 120         | 500    | 400    | 500    | 800    | 800    | 1300   | 750    | 500    | 550    | 700    |
| **Non-experts mean**                                          | 252         | 1778        | 366         | 309         | 110         | 460    | 452    | 512    | 810    | 890    | 754    | 668    | 620    | 731    | 673    |
V. DISCUSSION

This study has shown that experts in nutrition can estimate calories of meals using a photograph taken on a smartphone within +8% error, while non-experts with limited training were not successful (+55% error). When applied crowdsourcing to expert and non-experts, the same findings were found. However, crowdsourcing data showed that aggregating opinions from a crowd of experts and also a crowd of non-experts improves accuracy. When designing a personalized messaging system for obesity prevention and management using a mobile application, a crowd of experts in nutrition should be included to estimate calories in foods from photographs taken on a smartphone, which may have potential in contributing to obesity prevention and management.

This study had a limited sample size of 12 experts and 12 non-experts, further research studies could include larger sample sizes to determine if crowdsourcing has further potential in obesity prevention and management, and the impact of the crowd size on the reliability.

The results of this study have applications both for experts of nutrition/dietetics and non-experts. For the experts in nutrition/dietetics, as they can estimate calories in foods from a photograph within +8%, they can provide remote nutrition advice with confidence. This indicates increase accessibility for the general public to Nutritionists. For the non-experts, they can easily record of their food intake using a smartphone quickly without searching databases and entering names and amounts of foods. Further research is required to explore this the potential of crowdsourcing in obesity research further.

Overall, this study has clearly shown that crowdsourcing has increase potential in health including obesity research and practice.

ACKNOWLEDGMENTS

The authors would like to thank the participants for participating in this study.

REFERENCES


Table 2. The difference between experts (n=12) and non-experts (n=12) identifying calories (Kcals) of meals from photographs taken on a smartphone using crowdsourcing

<table>
<thead>
<tr>
<th>Difference from the accurate Kcals</th>
<th>Average Difference (Kcals)</th>
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<td>Everyone mode difference</td>
<td>33.53</td>
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<tr>
<td>Everyone mean difference</td>
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<tr>
<td>Non-experts mode difference</td>
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<tr>
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