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Smart-card-based automatic meal record system intervention tool for analysis using data mining approach

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Abstract

The Smart-card-based Automatic Meal Record system for company cafeterias (AutoMealRecord system) was recently developed and used to monitor employee eating habits. The system could be a unique nutrition assessment tool for automatically monitoring the meal purchases of all employees, although it only focuses on company cafeterias and has never been validated. Before starting an interventional study, we tested the reliability of the data collected by the system using the data mining approach. The AutoMealRecord data were examined to determine if it could predict current obesity. All data used in this study (n = 899) were collected by a major electric company based in Tokyo, which has been operating the AutoMealRecord system for several years. We analyzed dietary patterns by principal component analysis using data from the system and extracted 5 major dietary patterns: healthy, traditional Japanese, Chinese, Japanese noodles, and pasta. The ability to predict current body mass index (BMI) with dietary preference was assessed with multiple linear regression analyses, and in the current study, BMI was positively correlated with male gender, preference for "Japanese noodles," mean energy intake, protein content, and frequency of body measurement at a body measurement booth in the cafeteria. There was a negative correlation with age, dietary fiber, and lunchtime cafeteria use (R^2 = 0.22). This regression model predicted "would-be obese" participants (BMI $\geq$ 23) with 68.8% accuracy by leave-one-out cross validation. This shows that there was sufficient predictability of BMI based on data from the AutoMealRecord System. We conclude that the AutoMealRecord system is valuable for further consideration as a health care intervention tool.
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Keywords: Feeding behavior; Overweight; Nutrition assessment; BMI; Data mining

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion; BMI, body mass index; GI, glycemic index; GL, glycemic load.

1. Introduction

Obesity is a significant issue in Western countries [1]. Similarly in Japan, the prevalence of obesity in males has been increasing for the past 20 years and is now more than 30% for males in their 40s to 60s [2]. Moreover, a longitudinal analysis at the individual level demonstrated that the prevalence of obesity increased among middle-aged Japanese participants [3]. To prevent lifestyle-related diseases, especially visceral fat obesity, the Ministry of Health, Labor and Welfare, Tokyo, Japan, has issued an act that regulates health insurance unions. Under the act, these unions are to recommend an annual medical checkup for insured individuals between the ages of 40 and 75 and to conduct health guidance for those who are diagnosed with or at risk for metabolic syndrome [4].

Because most people at risk for metabolic syndrome are of working age, some companies have started to create environments that aid employees in improving their lifestyles [5-7]. The company cafeteria plays an important role in the diet of employees and has come under the spotlight. Although

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there are several methods for assessing intake of foods/nutrients, including weighed diet records, 24-hour recall, and food frequency questionnaires, few companies have attempted to monitor eating habits of all employees because available methods require tremendous amounts of time, effort, and money.

Recently, smart cards (pocket-sized cards with embedded integrated circuits that can process data) have become common as employee ID cards. An innovative system for company cafeterias has been developed to monitor employees' eating records using a smart card with an electronic wallet function. The smart-card-based Automatic Meal Record (AutoMealRecord system) relates point-of-sale purchase data to nutritional information per serving. For employees who registered, it also provides their nutritional records through email and its corresponding Web site [8]. The system also interfaces with body composition scales that have smart card readers. Employees can use their own dietary history and body composition records to improve their health.

The AutoMealRecord system was originally developed by an electric company as a commercially available health care service to make the smart-card-based system pervasive. Because of their withdrawal from the health care business, the AutoMealRecord system has only been operated in-house and received less attention, even within the company, for several years. Although the AutoMealRecord system only targets meals from company cafeterias, it is a unique nutrition assessment tool for automatically monitoring the meal purchases and body composition of all employees. One of the authors (SZ) had a chance encounter with the implementer of the AutoMealRecord system and saw massive potential in the system to be a powerful tool for health promotion and lifestyle disease prevention. So far however, the system has not received any validation as a nutrition assessment tool as it has only been used for providing a weekly nutrition summary to registered employees. We decided to assess the potential of the AutoMealRecord system as a preventive measure against lifestyle diseases. Before starting an interventional study though, it must be tested whether the data accumulated by the AutoMealRecord system is reliable as a diet record. We applied the data mining approach, which is commonly used in a wide range of profiling practices such as marketing and surveillance, to extract important patterns from large amounts of data [9]. We hypothesized that the AutoMealRecord system could explain current obesity status if the data were reliable as a diet record, and so, we explored whether data previously collected by the AutoMealRecord system could predict current obesity in this study.

2. Methods and materials

2.1. Participants and data sources

All data used in this study were collected through the head office of a major electric company based in Tokyo that has been operating the AutoMealRecord system for several years. We accessed the AutoMealRecord system database provided by Relieur-Interieur LLP, Tokyo, Japan, which recently administered the AutoMealRecord system outside the electric company with the nondisclosure agreement. There are 2 food service companies providing cafeteria-style dining at lunchtime and dinnertime. In September 2008, the administrator of the system sent an email to all permanent employees working at the office inviting them to register with the AutoMealRecord system. About 23% of them (n = 933) started using the system. Written informed consent was obtained from all participants at the time of registration.

All data used in this study were extracted from the AutoMealRecord system database on December 1, 2008. We were only able to access meal purchases and body composition records obtained from consenting participants and did not handle personal data such as names or contact information. Because all data used in our study were completely anonymous and secondary data, this study was started without an ethical review in compliance with the Ethical Guidelines for Epidemiological Studies [10]. However, the protocol of our project on the AutoMealRecord system (including this study) was approved by the ethics review board of the University of Tokyo (Japan).

The AutoMealRecord system (described in detail by Murakami [8]) has diners pay for their meals at a cafeteria terminal using an employee ID card with an electronic money function. All purchase data (electronic money ID, purchase date/time, code/quantity for each dish, and price) are stored on a central server. Nutritional information per serving (total energy, carbohydrate, protein, fat, salt, and fiber) and classification codes (food group, main ingredient, and cooking method) are delivered on a weekly basis to the database by national registered dietitians working for the cafeterias, under the supervision of Dr Ishida, Professor of Administrative Dietetics at Kagawa Nutrition University (Saitama, Japan). Each dish is also classified under 3 codes: food group, main ingredient, and cooking method (Table 1). Because of the complexity of laws regarding the details of the purchasing data such as the name of dish, we used these classification codes to track what was eaten.

The AutoMealRecord system database relates purchase data to nutritional information that it automatically saves. Employees who have registered with the AutoMealRecord system can check their daily diet record and nutritional balance by browsing the corresponding Web site (http://www.cooca.jp/fdk/index.php) that is protected by their unique IDs and passwords.

2.2. Meal purchasing-related data

To eliminate the effect of self-awareness, we analyzed the meal purchasing information that was stored in the

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