A hybrid framework for a comprehensive physical activity and diet recommendation system

Syed Imran Ali, Muhammad Bilal Amin, Seoungae Kim and Sungyoung Lee

Department of Computer Science and Engineering, Kyung Hee Univerity
{imran.ali, seoungae, sylee}@oslab.khu.ac.kr, m.b.amin@ieee.org

Abstract. The quantified self-movement has gained a lot of traction, recently. In this regard, research in personalized wellness support systems has increased. Most of the recommender systems focus on either calorie-burn or calorie-in take objectives. The achievement of calorie-burn objective is through physical activity recommendations while diet recommendations geared towards calorie-in take objectives. A very limited research is performed which track and optimize objectives for both calorie-burn and calorie-in-take, simultaneously based on well-known wellness support guidelines. In this regard, we propose a hybrid recommendation framework, which provides recommendations for physical activity as well as diet recommendation in order to support wellness requirements of a user in a comprehensive manner.

Keywords: Recommender System, Self-Quantification, Wellness Support System

1 Introduction

Over the years, there has been a huge surge in wellness support systems. These systems have varied capabilities from a relatively simple step count feature to a more complex wellness regiment-management [1]. Another reason for this renewed interest is due to availability of wearable and mobile technologies. These technologies assist not only in innovative application development but also do so in research such as in development of hybrid frameworks and subsequent field studies for their efficacy evaluation [2].

In order to induce a sustainable healthy behavior a number of aspects related to wellness require consideration. These aspects relate to the comprehensibility of the recommendation regimen and personalization of the recommendations. Existing popular wellness management systems such as Misfit shine [3] Jawbone Up [4] Fitbit Flex [5] provide recommendations based on very limited set of parameters e.g. steps count and slept hours, hence there is a room for a more comprehensive and personalized recommendation framework, which is capable of providing actionable recommendations, based on a number of personalized parameters. The scope of our research is limited to providing wellness support services focused on middle-age users through a knowledge based recommendation framework.

1.1 Expert-in-the Loop

Expert-in-the loop framework is yet another important consideration, which is under-researched in recommendation systems dealing with wellness support. This aspect of the recommender system deals with incorporating the domain expert curated information e.g. curated educational contents, for enhancing the general awareness of the user related to his/her peculiar less desirable habits. Moreover, domain experts e.g. nutritionists, can provide valuable input in menu construction for dietary recommendations. In this regard, our proposed framework deals with three key aspects of a wellness support regimen i.e. educational recommendation, physical activity recommendation, and dietary recommendation within the purview of enhancing the wellness of a target user pool.

Educational Recommendation: Educational recommendations assist in enhancing the awareness level of the user regarding the wellness domain. Moreover, factual nuggets embedded in the recommendation note also provide a rationale for adopting a balanced and active lifestyle that is elaborated by providing activity and dietary recommendations.

Physical Activity Recommendation: The physical activity recommendation is targeted to meet objectives stipulated in the calorie-burn goal. Whereas, the estimated calorie-burn goal is computed based on wellness guidelines in an automated manner. In this regard, the personalization element of the recommendation is also incorporated by assessing the contextual situation of the user at a given time of recommendation [6].

Dietary Recommendation: Dietary recommendation caters for the specific needs of a user in terms of calorie-in take requirements, as estimated from wellness guidelines, and health conditions e.g. diabetic patients are recommended low-glycemic food items. Another important factor of dietary recommendation regimen is the incorporation of local/territorial food information regarding the unsuitability of certain food items for consumption due to seasonal or viral containments. Expert(s) constructs menu-sets for each goal category and the system after multi-factor filtration provides the final recommendation [7].

2 Related Work

The There has been an extensive research performed in the area of wellness related recommender systems. These systems are geared towards either physical activity based recommendation or dietary recommendation. Comprehensive systems, as an area of inquiry, the recommendation systems targeting both physical activity and dietary recommendation, are under-researched. In this section, we will provide an overview of an array of recommender systems. Our main focus is on the comprehensive recommender systems.

Recommendation systems, which provide recommendations regarding physical activity normally, employ user's contextual information. Contextual information based on different parameters such as location, current activity, weather information, etc. is poised to provide a holistic situational context. Such a situational context may

be explored to determine various important factors such as user interruptibility and suitability of a recommended physical activity for the given user context.

Dietary recommender systems specifically focus on the calorie-in-take goal. Moreover, these systems provide user with recommendation, which includes food items that collectively contribute in achieving the stated goal. Goal maybe user defined or expert recommended based on health condition and suitability constraints. In this regard, both expert advised menu-sets and system generated menu-sets maybe used. Our proposed framework has adopted the former approach.

Acquiring an elaborate contextual user information is not straightforward. Moreover, it necessitates the inclusion of supporting modules which can provide accurate and timely contextual information about a user e.g. location, current activity, emotional state, etc. Although, the inclusion of such supporting modules may add to the complexity of the system, it is a requisite step towards the comprehensibility of the recommender system. Hence, when available the recommendation framework should be able to utilize such contexts as aforementioned. Following are some of the existing systems for physical activity recommendation.

PRO-Fit is a personalized physical activity recommender. It provides personalized workout session recommendations. Contextual data is collected through accelerometer. This data is later synchronized with user's weekly plans [8].

The Runner [9] is another popular recommender systems for users who prefer running activity, geared towards the wellness needs of a specific group of users. It provides both physical activity and nutritional recommendations to users. Although it processes an array of contextual parameters, its physical activity recommendation is primarily oriented towards running.

A web based compressive recommender system is proposed by [10]. The proposed system is capable of processing a wide array of contextual parameters such as demographic information, health conditions, religious information, etc. Since sensory data is not taken into account, therefore system falls short of dynamically adapting to contextual requirements of the user.

Faiz et al. [11] proposed a comprehensive wellness support system for patients suffering from diabetic ailments. Semantic technologies such as ontology engineering is investigated in this work in order to provide wellness related recommendations.

A comprehensive web-based recommendation system and a six-week evaluation study is performed by [12]. This system is evaluated based on technology acceptance model. Although system is capable enough to cater for the basic needs of its targeted user group, it lacks comprehensibility in terms of handling a wide array of contextual factors e.g. user's location.

Aforementioned are a sample of studies, which addressed wellness support through designing comprehensive recommender systems/frameworks. Although most of the studied systems in this research are capable enough to address basic user needs, their comprehensibility in terms of processing multi-factor contextual information and assisting user in adopting healthy habituation (e.g. user awareness towards wellness through educational nuggets) is lacking.

In the subsequent section, we propose a comprehensive wellness support system which caters for educational, active-lifestyle and nutritional needs of a targeted user group.

3 Proposed Framework

Our proposed system is composed of a number of modules. These modules are divided into two categories i.e. main module and supporting modules. Main module represents the main working engine of the framework while the supporting modules provide services to the main module. Hence, the main business logic of the recommender resides in the multi-stage recommender system module as depicted in Fig. 1.

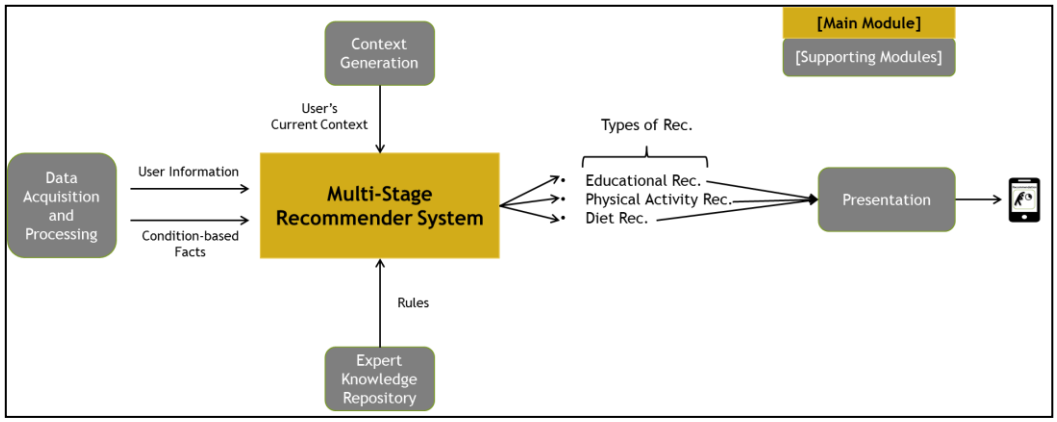

Fig. 1. Abstract level overview of the main and supporting components of the proposed framework

Data Acquisition and Processing module acquires data from the sensory devices e.g. mobile phone, processes the required information and persists it. Moreover, this module is also tasked with storing personal information about the user i.e. demographic information, preferences related information, etc. A monitoring application resides in this module which tracks user's activities, food consumption (entered manually) and calculates a multi-factor vector regarding user's food consumption so far and activity-level. Each factor vector corresponds to a particular "situation".

Context Generation module processes sensory raw data into meaningful user contexts such as user's current activity, location of the user, weather conditions, user's emotional state, etc. This information is very valuable for providing context-aware physical activity based recommendation.

Expert Knowledge Repository module stores expert knowledge in terms of production rules. These rules are based on fact vectors. Against different situations there are different kinds of recommendations. These generic recommendations are stored in IF-THEN form i.e. IF clause of the rule captures the situation part while THEN clause denotes recommendation given by an expert in the given situation.

Presentation module deals with interfacing with the user's device i.e. mobile phone. A recommendation package is sent to the Presentation module. Presentation module presents the generated recommendation in a user-friendly manner.

Multi-Stage Recommender System is the main module which deals with processing the provided contextual information along with user profile, and situational information in order to provide a comprehensive recommendation. Stage-I of the module deals with calculating user's calorie-burn, in-take goals and a generic set of physical activity recommendation. It also has a case-based reasoning mechanism through which it infers the most appropriate rule from the knowledge base. Stage-II deals with refining the recommendation in a more personalized manner. For physical activity recommendation, Stage-II recommender creates a context matrix through which it infers which of the activities can be recommended to a user at a given time. Moreover, it is tasked with selecting the most appropriate menu-set based on goal, situational-fact vector, and user preferences. Providing educational recommendation is also the task of this component.

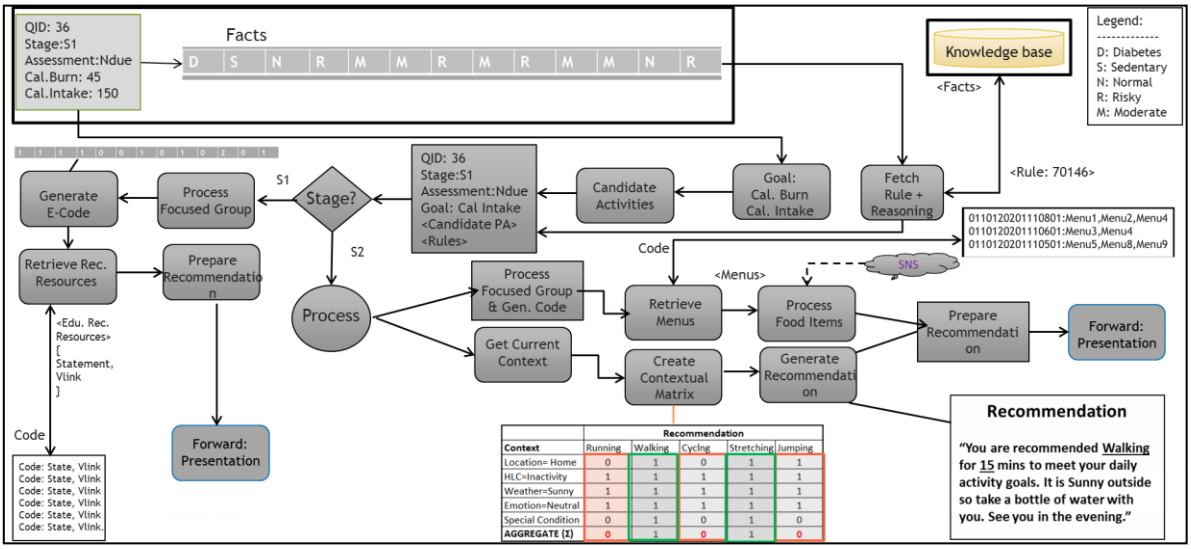

Fig. 2. Execution Scenario for Educational, Physical activity and Dietary Recommendation

In Fig 2. a working scenario of the recommender system is depicted. Where S1 and S2 correspond to users in two different stages. S1 users are only provided Educational Recommendation for the first week. Educational recommendation is in the form of a text message, along with curated educational material in terms of web links, pictures, and video links, etc. Users in S2 category are provided with physical activity and dietary recommendation.

3.1 Rule-Structure for Interpretation and Recommendation generation

Knowledge base contains rules which are used for generating recommendations. Rule has components i.e. condition part, recommendation part, and an optional description part. Condition part corresponds to the situational vector which encapsulates a user's current situation in terms of physical activity, health status,

weight status, fat consumption level, salt and sugar consumption level, protein consumption and food and vegetables consumption, etc. Recommendation component of the vector deals with the subset of the conditions in the situation which are risky and require a recommendation for improvement.

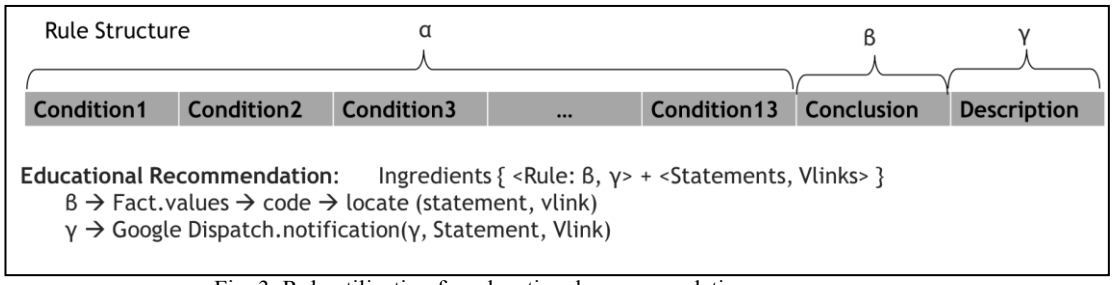

Fig. 3. Rule utilization for educational recommendation

For example, if fat consumption and BMI of the user are abnormal then these two conditions would be part of Recommendation component. Description part of the rule accommodates a free text observation by the domain expert. Fig 3 and Fig 4 depicts how a rule is utilized a different kinds of recommendation i.e. educational, physical activity, and dietary. It is important to note that an index mechanism is used to locate menu-sets for dietary recommendation. A code is generated based on conditions values augmented with the category of the calorie-in-take goal. Category of the goal is divided into four groups i.e. A, B, C, D, having mutually exclusive ranges.

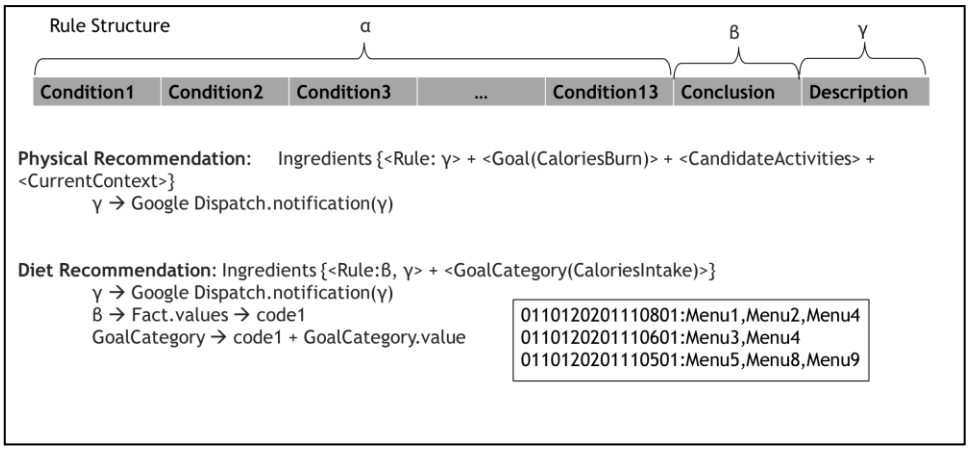

Fig. 4. Rule utilization for both physical and dietary recommendation

3.2 Two-Stage Context-aware Physical Activity Recommender

Multi-stage recommendation module has two sub-components i.e. Stage-I and Stage-II recommenders. In order to generate a physical activity recommendation first goal is

computed for the given user. This goal is based on the formulae provided in wellness guidelines. Subseqently, MET based formula is used to calculate different physical activities and their durations which can meet the stipulated goal. This generic information along with contextual information is fed to Stage-II recommender. This component, generates a contextual matrix. This contextual matrix is computed based on surveyed results in which users were asked to provide their input regarding the suitability of a particular physical activity in different contexts. For example, Running was deemed not suitable when user is in Home while Stretching was deemed a reasonable recommendation in this context. Once a recommended activity is determined then it is conveyed in a user friendly way. This process is depicted in Fig. 5.

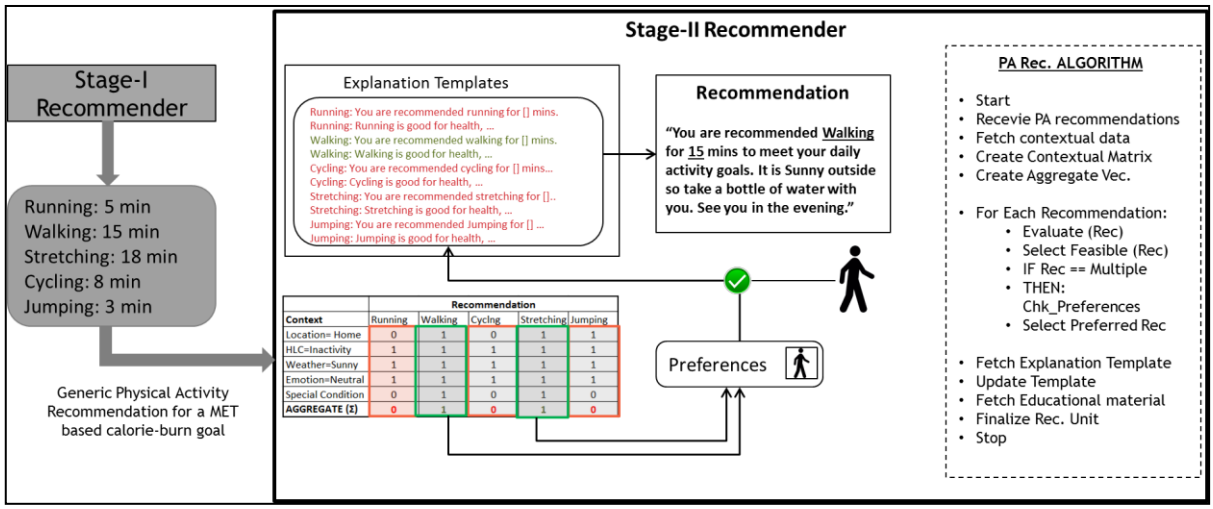

Fig. 5. Scenario for a physical activity recommendation

A similar recommendation mechanism is used for diet recommendation. Stage-I recommender computed the calorie-in-take goal of a user. Category of the goal is determined and all the expert curated menu-sets associated with the category are retrieved. If there are multiple menu-sets then in order to select one menu-set a filtration process is invoked. This filtration process takes into account the user disliked food items in each candidate menu-set and those food items which are tainted and have a government advisory for abstinence. The menu-set which has the least such food items as aforementioned is selected for a final recommendation. The process of dietary recommendation is depicted in Fig. 6.

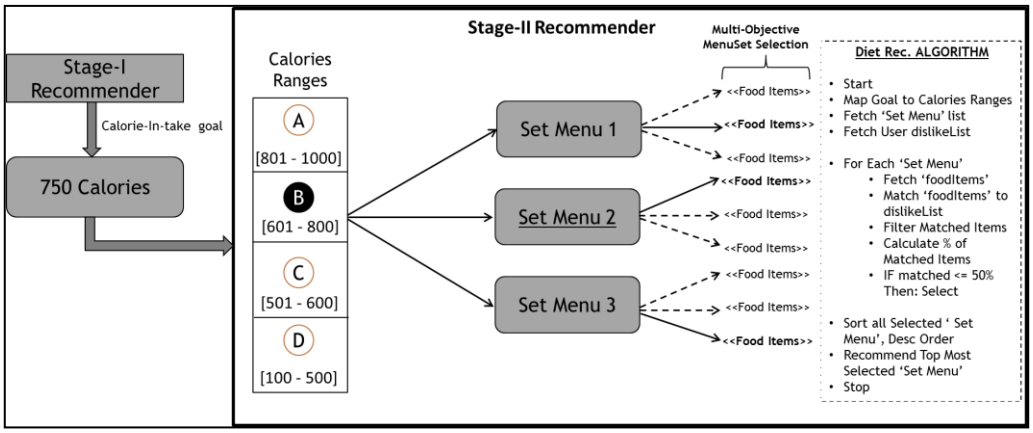

Fig. 6. Scenario for dietary recommendation

4 Conclusion and Future Work

In this research work we have proposed a hybrid framework for a comprehensive wellness support framework. Our proposed framework is capable of providing physical activity based recommendation, dietary recommendation as well as educational recommendations to a selected targeted user group. Moreover, we have also catered for personalization aspects of the recommender system as well. Through expert-in-the loop mechanism, our framework is capable of providing educational recommendations to the user base. A multi-factor menu-set recommendation is also geared towards the specific nutritional needs of the users. The proposed approach combines different facets of wellness support systems in a holistic manner in order to provide a more comprehensive treatment to the specific needs of the users.

In future, we would like to extend our work in a number of directions. Educational contents can be pre-curated automatically for the expert and later domain expert can sift through the pre-curated recommendations. A feedback mechanism maybe introduced which monitors whether user has acted upon the given recommendation or not and record user's opinion regarding the generated recommendation. In terms of menu-set selection, a more automated approach may be investigated which can generate reasonable menu-sets under certain constraints.

Acknowledgement

This research was supported by the MSIT(Ministry of Science and ICT), Korea, under the ITRC(Information Technology Research Center) support program(IITP-2017-0-01629) supervised by the IITP(Institute for Information & communications Technology Promotion)" and by the Korea Research Fellowship Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (NRF-2016H1D3A1938039)

References

1. Chan, V., Ray, P., & Parameswaran, N. (2008). Mobile e-health monitoring: An agent- based approach. Communications, IET, 2 (2), 223–230. https://doi.org/10.1049/ iet-com.
2. Asabere, N. Y. (2013). Towards a viewpoint of context-aware recommender systems (CARS) and services. International Journal of Computer Science and Telecommuni- cations, 4 (1), 10–29 Retrieved from http://www.ijcst.org/Volume4/Issue1/p4 _ 4 _ 1. pdf.
3. Misfit: Fitness Trackers & Wearable Technology –Misfit.com. Retrieved March 6, 2018, from https://misfit.com/.
4. AliphCom dba Jawbone. (2014). Jawbone UP Retrieved March 6, 2018, from https:// jawbone.com/up
5. Fitbit. (2018). Retrieved March 6, 2018, from https://www.fitbit.com/kr/home
6. Verbert, K., Manouselis, N., & Ochoa, X. (2012). Context-aware recommender sys- tems for learning: A survey and future challenges. IEEE Transactions Retrieved from http://ieeexplore.ieee.org/abstract/document/6189308/
7. Gómez-Sebastià, I., & Moreno, J. (2016). Situated agents and humans in so- cial interaction for elderly healthcare: From Coaalas to AVICENA. Jour- nal of Medical Systems Retrieved from http://link.springer.com/article/10.1007/ s10916-015-0371-7.
8. Dharia, S., Jain, V., Patel, J., Vora, J., Chawla, S., & Eirinaki, M. (2016). PRO-Fit: A personalized fitness assistant framework. 28th international conference on soft- ware engineering and knowledge engineering . Redwood City, CA: SEKE https: //doi.org/10.18293/SEKE2016-174 .
9. Donciu, M. , Ionita, M. , Dascalu, M. , & Trausan-Matu, S. (2011). The runner–Rec- ommender system of workout and nutrition for runners. In 2011 13th inter- national symposium on symbolic and numeric algorithms for scientific computing (pp. 230–238). IEEE .
10. Charles, E., Stanley, D., & Agbaeze, E. (2013). Knowledge-based diet and physical exercise advisory system. International Journal of Science and Research (IJSR), 14 (7), 2319–7064. Retrieved from http://www.ijsr.net/archive/v4i7/SUB156493. pdf . ISSN (Online Index Copernicus Value Impact Factor) .
11. Faiz, I., Mukhtar, H., & Khan, S. (2014). An integrated approach of diet and exer- cise recommendations for diabetes patients. e-Health Networking, Applications Retrieved from http://ieeexplore.ieee.org/abstract/document/7001899/ .
12. Omar, A., & Wahlqvist, M. (2005). Wellness management through Web-based pro- grammes of telemedicine and…Retrieved from http://journals.sagepub.com/doi/ abs/10.1258/1357633054461985 .