Online health promoting communities
Design, implementation and formative evaluation of an intervention

Joakim Ekberg
“Mr. Bell, after careful consideration of your invention, while it is a very interesting novelty, we have come to the conclusion that it has no commercial possibilities.”

-- J. P. Morgan’s comments on behalf of the officials and engineers of Western Union.
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ABSTRACT

In Sweden, obesity among children has not yet reached the epidemic proportions reported from other parts of the world. However, among adolescents, being overweight and self-consciousness regarding body shape, diet and exercise influence social, psychological and physical health. Obese children may be in need of secondary prevention because of adverse effects related to obesity, but it is less obvious exactly what to prevent in the rest of the population. General interventions to prevent overweight and obesity are problematic because of the lack of associations for general application; there is a need for personalized community-based health promotion. Online interventions are especially suitable considering the amount of time adolescents spend online.

This thesis takes a design approach to interventions and describes the design of an online health promoting community as a path to health promotion among adolescents. The first two studies use data from the first 15 years of a 1991 cohort living in Östergötland to determine the predictability of obesity from childhood body mass index and to investigate interventions and available evidence to suggest appropriate interventions. The next two studies use these findings to design and formatively evaluate a health promotion intervention.

In Study I we found reasons for offering population-based interventions systematically from 5 years of age. It would be worthwhile identifying at an early age those relatively few children with substantially increased risk of maintaining obesity in adulthood and offering them interventions; but interventions must be avoided when they are not necessary. The projections in Study II indicate that more specified interventions would benefit adolescents without increasing the costs. In Study III, we found than an online health promoting community can be designed simply at relatively low cost and can be negotiated to satisfy both the needs of the user community and public health goals and service capabilities. In Study IV, a checklist for pre-launch evaluation of online health promoting communities was developed and the most important result was the delicate balance between community autonomy and quality control. Future studies addressing health outcome constructs for use in online health promoting community evaluations are warranted.
LIST OF PAPERS

The thesis is based on the following papers, which are referred to in the text by their Roman numerals:


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The project was approved by the Ethics Committee of Linköping University, Dnr: 033-600 and Dnr: 478-31.
PREFACE

This thesis follows the tradition of social medicine and public health in that a population is examined and an intervention devised in analogy to a doctor–patient relationship. I came to the field of social medicine from cognitive science and found the concept of not only trying to understand behaviours of cognitive systems but also, based on observation and theory, taking action to design interventions to prevent disease and promote health exciting and liberating.

The most prominent observation I have made is that design methodology harmonizes astoundingly well with intervention design in social medicine and public health, in that user needs are central and designs are evaluated based on benefit.

Research is rather difficult, and even though this is my thesis, I have only done a very small part of the overall efforts described herein. Without mentors in academia and public health, my work would at best be an overview of the literature.

I am sincerely grateful and humbled by the warm welcome into social medicine I have had the pleasure to experience and I look forward to contributing in years to come, albeit with but a small part, to social medicine practice.

Joakim Ekberg
In Sweden, obesity among children has not yet reached the epidemic proportions reported from other parts of the world\textsuperscript{1-3}. However, among adolescents, being overweight and self-consciousness regarding body shape, diet and exercise influence social, psychological and physical health\textsuperscript{4-6}. Obese children may be in need of secondary prevention because of adverse effects related to obesity\textsuperscript{7}, but it is less obvious what exactly must be prevented among the rest of the population. General interventions to prevent underweight and obesity are problematic because of the lack of associations for general application\textsuperscript{4,8}; there is a need for personalized community-based health promotion\textsuperscript{9}. Online interventions are especially suitable considering the amount of time adolescents spend online\textsuperscript{10}.

**Obesity**

Obesity is commonly defined as excessive accumulation of fat in adipose tissue to the extent that health may be impaired\textsuperscript{11}. In population surveys, body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters) or Quetelet’s index, is commonly used as a proxy for body fat content\textsuperscript{12}. BMI has been shown to have a weak correlation with height and a strong correlation with body fatness in adults\textsuperscript{13,14}, although this relationship varies according to body composition and proportions\textsuperscript{15}.

According to a survey conducted in 2009, the prevalence of obesity among adults in Sweden is 12% (13% in females, 12% in males) measured using a self-administered questionnaire\textsuperscript{16,17} (Table 1), and the corresponding prevalence of overweight is about 33% (27% in females, 41% in males). The prevalence of obesity has increased nationally over time\textsuperscript{16-21} (Table 2), however, compared with the rest of the world, the prevalence in Sweden and in other Nordic counties such as Denmark\textsuperscript{22} (11.4%) is modest. The highest prevalence of obesity in first-world counties is found in the United States\textsuperscript{23} (35.6%), New Zealand (26.5%), Canada\textsuperscript{24} (23.1%), and the United Kingdom\textsuperscript{25} (22.7%).
Introduction

Table 1. Prevalence of adult overweight and adult obesity in Sweden

<table>
<thead>
<tr>
<th></th>
<th>Overweight*</th>
<th></th>
<th>Obese</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
<td>Female</td>
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<tr>
<td><strong>Ethnic group</strong></td>
<td></td>
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<td>.38</td>
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<td>.14</td>
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<td>Other Nordic countries (ethnic group)</td>
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<td>.45</td>
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<td>.18</td>
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<tr>
<td>Rest of the world (ethnic group)</td>
<td>.21</td>
<td>.41</td>
<td>.29</td>
<td>.16</td>
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<tr>
<td>Sweden (ethnic group)</td>
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<td>.41</td>
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<tr>
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<td>Long education</td>
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<td>.34</td>
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<td>.06</td>
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<td>Medium education</td>
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<td>.42</td>
<td>.33</td>
<td>.09</td>
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<tr>
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<td>.32</td>
<td>.32</td>
<td>.25</td>
</tr>
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<td>.20</td>
<td>.18</td>
<td>.19</td>
<td>.13</td>
</tr>
<tr>
<td>Unemployed</td>
<td>.54</td>
<td>.46</td>
<td>.50</td>
<td>.17</td>
</tr>
</tbody>
</table>

*Excluding obesity

According to the World Health Organization (WHO), at least 2.8 million adults die each year as a result of being overweight or obese. In addition, 44% of the diabetes burden, 23% of the ischaemic heart disease burden and between 7% and 41% of certain cancer burdens are attributable to overweight and obesity (http://www.who.int/mediacentre/factsheets/fs311/en/).
Table 2. Prevalence of obesity over time in Sweden

<table>
<thead>
<tr>
<th>Year</th>
<th>Obesity (%)</th>
<th>Sample size</th>
<th>Age (years)</th>
<th>Method and source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>12.0</td>
<td>20348</td>
<td>16–84</td>
<td>Self-administered questionnaire</td>
</tr>
<tr>
<td>2000–2001</td>
<td>9.2</td>
<td>22706</td>
<td>16–84</td>
<td>Interviewer-administered questionnaire</td>
</tr>
<tr>
<td>1998–1999</td>
<td>8.1</td>
<td>22698</td>
<td>16–84</td>
<td>Interviewer-administered questionnaire</td>
</tr>
<tr>
<td>1997</td>
<td>7.0</td>
<td>11417</td>
<td>15–100</td>
<td>Self-administered questionnaire</td>
</tr>
<tr>
<td>1996–1997</td>
<td>7.0</td>
<td>3781</td>
<td>16–84</td>
<td>Self-administered questionnaire</td>
</tr>
<tr>
<td>1988–1989</td>
<td>5.4</td>
<td>3402</td>
<td>16–84</td>
<td>Self-administered questionnaire</td>
</tr>
<tr>
<td>1980–1981</td>
<td>5.1</td>
<td>14476</td>
<td>16–84</td>
<td>Physical measurement</td>
</tr>
</tbody>
</table>

The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. The increase in obesity globally can be accredited to an increased intake of energy-dense foods that are high in fat, salt and sugars but low in vitamins, minerals and other micronutrients in combination with a decrease in physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization (http://www.who.int/mediacentre/factsheets/fs311/en/).

Childhood obesity

Childhood obesity is associated with a higher risk of persistent obesity, premature death and disability in adulthood. But in addition to increased future risks, obese children experience breathing difficulties, increased risk of fractures, hypertension, and early markers of cardiovascular disease, insulin resistance and psychological effects. According to the WHO, the number of overweight children under the age of 5 years in 2010 is estimated to be over 42 million. However, estimates of childhood obesity are problematic because BMI, as used to determine obesity, assumes full height.

BMI is not well suited for the purpose of measuring obesity in children during development and alternate measurements have been used, such as relative measurements whereby children over the 80th percentile of BMI for their age and gender are said to be overweight, and children over the 95th percentile are said to be obese. Because this measurement is relative, a baseline measurement, the International Obesity Task Force (IOTF) criteria, was
introduced to make comparisons possible, based on almost 200 000 individuals; adult BMI values were used to determine corresponding age- and gender-specific BMI values suitable for children. Using longitudinal BMI data in adulthood categories as reference, age-specific childhood BMIs have been identified for classifying children as normal weight, overweight, and obese\textsuperscript{29}, and later also underweight\textsuperscript{30}. These categories have been reported to have high specificity but low sensitivity for predicting obesity and metabolic disorders in young adulthood\textsuperscript{31}.

It is thus an important aspect of working with risk groups that these individuals are not considered to be diseased but at risk, and that epidemiological findings do not necessarily hold for all individuals. The age-specific childhood BMI value for obesity is not obesity as such, but is nevertheless sometimes carelessly regarded as childhood obesity. When talking about children classified as overweight, this problem becomes even more entangled. A child classified as overweight according to the age- and sex-adjusted childhood BMI criteria\textsuperscript{29} is thus at risk of being overweight in adulthood, which in turn is considered a risk factor for obesity.

**PREVIOUS RESEARCH**

The irregular distribution of obesity within and between countries demonstrates that lifestyle and social determinants have a significant influence on the prevalence of obesity. The relative impact of the determinants is unclear, but unhealthy diet, lack of exercise and a sedentary lifestyle have frequently been put forth as factors\textsuperscript{32}. One influential approach to lifestyle changes has been various modes of providing information\textsuperscript{33}. The purpose of such interventions has been to increase awareness and knowledge, modify attitudes and, as a result, alter behaviour\textsuperscript{34}.

Community interventions follow five fundamental steps\textsuperscript{34}. In the first step, a community analysis to determine the assets, capacity and history of a local community is performed. Analysis is the critical first step in shaping the design of campaign interventions, and it is important to involve members of the community at this stage. This provides the basis for an informed approach to the second step, to design and initiate a campaign. A group of citizens and professionals make preliminary decisions about objectives and interventions.
The third step of implementation involves transforming the ideas into action, with feedback and monitoring. The fourth step involves refining the programme by reviewing the successes and problems. In the fifth step, dissemination and durability, information on the project results and plans for the sustainability of the projects are clearly communicated.

**Web-based interventions**

Recently, some health care services have moved from traditional health care settings into Internet-based forums, patient-governed Internet information sites, and support groups for disease self-management. The well-documented practice of computer-assisted therapy has moved from dedicated workstations to the Internet, which has increased its availability and lowered the demands on resources.

There is now evidence that computer-based interventions outperform traditional media regarding physical activity among adolescents, but there are also other studies that show no such difference. In a recent review of computer- and web-based interventions to increase psychical activity among adolescents, most interventions resulted in a significant increase in physical activity, but the findings were short lived. Parental support has been shown to be decisive for physical activity in a complex intervention with computer-tailored feedback and changes to the school environment. However, not all new interactivity is beneficial and there is probably some overconfidence in the bells and whistles of interactive media, such as interactive games. In a study where games, quizzes, etc. were compared with traditional information provision, traditional printed material actually outperformed the interactive media approach.

A review by Hamel et al. concluded that factors contributing to successful interventions included conducting interventions at schools and using a theory or model as framework. Common theories used in computer- and web-based interventions include Social Cognitive Theory, the Transtheoretical Model, the Health Belief Model, the Theory of Planned Behaviour, and attitude, social influence, social influence and self-efficacy models. Previous research also indicates that parental support is beneficial to the outcome of web-based interventions. Research on adolescent obesity demonstrates that overweight adolescents are prone to use web-based interventions, and that
due to the usually short-lived effects, one-shot interventions with minimal supervision may not be the optimal solution\textsuperscript{56}.

**Non-adherence**

The cognitive view of behavioural change can be summarized as requiring that the intended recipients understand that they have a problem and are aware of available treatment, commit to treatment whereby they are prepared to perform often uncomfortable actions in divergence with their current behaviour and beliefs, and persist in follow-up of the treatment when faced with obstacles and difficulties in the treatment. However, a large proportion of individuals who commit to behavioural change interventions fail to complete the treatment for various and mostly unknown reasons\textsuperscript{57}.

Adherence is sometimes defined as the extent to which a patient’s behaviour on health matters coincides with medical advice\textsuperscript{58}. Non-adherence to interventions is a persistent and elusive phenomenon in health care and public health. The refractory nature of this problem has led to the situation whereby some level of non-adherence has come to be routinely accepted in the planning of health interventions. Children with obesity and their parents are often fully aware of the health risk of obesity, the strategies available to reduce weight and become healthier, as well as the health benefits of reducing weight. Risk information programs have been plentiful in this area and many children also have a strong desire to lose weight, but fail to follow-up on the available interventions. Some are unwilling to commit to lifestyle changes and break unhealthy habits, and others make efforts but fail to maintain vigilance in their efforts. Thus, both these groups are in need of support rather than even more information (Figure 1).
Introduction

Figure 1. Non-adherence in behavioural health interventions.

Online health promoting communities

An online community refers to a gathering of individuals in a virtual space who form a network of long-term public discussions on common interests or experiences. As a result of the prevalent use of the Internet and novel social media, the community concept is no longer limited to physical locations. In contrast to traditional communities focusing on learning and mastery of physical tasks and activities, the emphasis in online communities is on learning and information exchange.

Advances in web-based technology have recently made online communities a relatively inexpensive and potential alternative for health promotion, especially in the area of self-directed and informal learning. Self-directed learning, where the individual is in command of what should be learned, stands in contrast to health education where health experts provide information they think that the recipients need. Informal learning has been said to have more significance for knowledge accumulation than formal education or training. The motivation of an individual to use an online community is contingent on their perception of the usefulness of the community in their specific cultural, social, and technical context. Only when a community is perceived useful and used by a critical amount of users can a community flourish.

In addition, public health interventions have recently been adjusted for delivery and evaluation in online environments. These interventions have
usually focused on the prevention of specific impairments\textsuperscript{66,67} and reaching adolescents and young adults\textsuperscript{64,68}. Web-based disease prevention has matured into a relatively inexpensive and potential alternative; however, few studies have been published on web-based health promotion\textsuperscript{69,70}.

The development of open source and easy-to-use content management systems (CMSs) has made it possible to put a system for an online community into action with relatively little effort and without the need for specialized competence in software development and management. Despite the apparent potential of online health promoting communities, not much guidance is available for developers on the basic design features characterizing successful applications. An online health promoting community has the potential to promote health and advance new means of dialogue between public health representatives and the general public. However, an online health promoting community must be managed and even if advances in web-based technologies simplify the initiation of online communities, management and maintenance must be sustainable in a responsible manner.
Design deals with engineering of tools with a specific purpose in mind. A thing, process or action is teleological when it is the means to an end, i.e., a *telos* or final cause. In science, teleological explanations are deliberately avoided since the *Novum Organum* of Francis Bacon, because whether they are true or false is argued to be beyond the ability of human capacity to judge. Whereas the natural sciences are void of teleological components, or at least expected to be, the artificial world makes no sense without purpose. Purpose is both the explanation of a tool, a tool is made for a specific purpose, and the measurement to which a tool is evaluated. Specifically, the design of a tool is the method by which to make something fulfil a specific purpose, and a tool is successful only when it can be shown to fulfil the purpose for which it is designed. Whereas natural science deals with hypotheses and theories in which phenomena are explained and outcomes predicted, design deals with tools and systems, where implementations are evaluated (Table 3).

<table>
<thead>
<tr>
<th>Study setting</th>
<th>Natural science</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenomenon</td>
<td>Hypotheses and theories</td>
<td>Tools and systems</td>
</tr>
</tbody>
</table>

The context in which a tool is going to be used is of paramount importance, not just because the tool is designed for a specific context but also because the introduction of a new solution to a problem will alter the problem for which the solution is designed. This alteration is in part deliberate, referred to as canonical performances, but also in part unexpected, referred to as exceptional performances. The alteration of context is sometimes referred to as task and system tailoring where the use of a new solution is adopted. The study of canonical and exceptional performances has led to discoveries of often serious misfortunes when introducing new tools, and has led to increased
consideration for exceptional performances detrimental to the context in which they are to be implemented.77

Design methodology

Design methodology is an interdisciplinary field involving research from architecture, engineering and industrial design and was consolidated as a scientific topic half a century ago. Design methodology governs methods to design or adjust systems in order to satisfy some desired need, whether it is a bench to rest upon when rest is needed, an information system to store massive epidemiological data when data needs to be securely stored, or a computer program to compile reports when reports need to be produced. Originally, design methodology was seen as pure engineering and problem solving, but later evolved into a more creative field.

The term design is used extensively in everyday language and it is easy to confuse and misunderstand what design denotes in the absence of a very specific context. One central concept of design methodology is to separate its construction on the one hand and the services it is supposed to provide and its place in an organization on the other. Even though “to design” colloquially is used to denote the actual construction of something, this is contrary to what design denotes in design methodology. Design is rather the process of determining what should be constructed.

Information systems design

The activity of design is to identify needs, establish requirements, develop alternative solutions, build prototypes and evaluate competing solutions. This means that during the process, the design will evolve based on repeated evaluations of an iteratively adapted specification. This process is theoretically without solution, only resolution, since new users and changes within the user group context will change over time, also by the design (re)solution itself. A pragmatic solution to this process in software development is to release and even sell an unpolished implementation. This has been made possible with the advent of the Internet through patches and upgrades after release; for example, the numerous updates in operating systems such as Microsoft
Theoretical background

Windows® and Mac OS® and programs such as Microsoft Office® and iTunes®. This reflects back to the inherent “wickedness” of design problems, that the solution and the problem are essentially the same; it is thus seemingly impossible to take a step-by-step approach to design problems73.

EVALUATION OF INFORMATION SYSTEMS

Measurements in evaluation of information systems have varied over time and between traditions from acceptance79, adoption80, user satisfaction81, system effectiveness82, information influence83, individual and organizational impacts84 to just not a failure85. Modern measurements of the success of information systems stems from two originally rather disparate traditions. On the one hand, methods and models have been developed from a systems perspective whereby the measure of success of the implementation of an information system is done via individual and organizational impact, or net benefit84,86,87. On the other hand, methods and models have been developed from a cognitive perspective to understand the use behaviour, and to measure the success of an information system via use and user satisfaction88,89. Even though use and user satisfaction is central in modern design evaluation, it has been argued that user satisfaction alone cannot fully measure information system success87.

Information system success

Evaluation of the success of the information systems in DeLone and McLean’s model84,86 stems from the communication model of Shannon and Weaver82,90 and the information influence theory of Mason83. Much information system management research, model validation, and model extensions have been done since DeLone and McLean originally presented their model, especially regarding the nature of use and the different levels of impact, and the complications of having a model with the characteristics of both a process model and a causal model87. The updated model presented in 200387 is both simpler and more complex. It adds service quality to the two original system characteristics and combines the two impact variables into one: net benefit (Figure 2).
The theoretical background section discusses the information system success model, which proposes that a system can be evaluated in terms of information, system and service quality; these characteristics affect the subsequent use or intention to use and user satisfaction. As a result of using the system, certain benefits will be achieved. The net benefits will (positively or negatively) influence user satisfaction and the further use of the information system (Table 4). However, DeLone and McLean stress the importance of context when using their model and encourage adoption of variables from their general model to suit the context for which the model is going to be used.

Figure 2. Information systems success model. The information system success model proposes that a system can be evaluated in terms of information, system and service quality; these characteristics affect the subsequent use or intention to use and user satisfaction. As a result of using the system, certain benefits will be achieved. The net benefits will (positively or negatively) influence user satisfaction and the further use of the information system (Table 4). However, DeLone and McLean stress the importance of context when using their model and encourage adoption of variables from their general model to suit the context for which the model is going to be used.
Table 4. Variables in the information system success model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>System quality</td>
<td>The accuracy and efficiency of the communication system that produces information</td>
</tr>
<tr>
<td>Information quality</td>
<td>The success of the information in conveying the intended meaning</td>
</tr>
<tr>
<td>Service quality</td>
<td>Tangibility, reliability, responsiveness, assurance/trust and empathy/benevolence of the provided service</td>
</tr>
<tr>
<td>Intention to use/use</td>
<td>Either an attitude variable (intention to use) or a behavioural variable (use)</td>
</tr>
<tr>
<td>User satisfaction</td>
<td>User rating or feedback of the information system</td>
</tr>
<tr>
<td>Net benefit</td>
<td>Context sensitive measure of the users net benefit depending on the aim of the information system</td>
</tr>
</tbody>
</table>

Technology acceptance models

In contrast to the communication effectiveness approach in information system success, another tradition of information system evaluation stems from a more user-centred approach, based on research in social psychology. The technology acceptance model developed by Davis initially incorporated the theory of reasoned action developed by Fishbein and Ajzen to explain computer use behaviour. Fishbein and Ajzen’s theory has been used as the basis for several information technology acceptance models and is based on attitude and intention, and assumes that behaviour is determined by intention to perform the behaviour.

Ajzen later extended the theory of reasoned action to the theory of planned behaviour to better address behaviours not completely in the user’s control by adding the construct subjective norm. Theory of planned behaviour has been used extensively in the health care context and assuming that intention predicts behaviour can be used to predict behaviour (Figure 3). Due to the observation that even if people have the intention of carrying out an action, the actual action is thwarted because they lack confidence or control over behaviour, the theory of planned behaviour takes into account self-efficacy, influenced by the social cognitive theory of Bandura.
Venkatesh and Davis\textsuperscript{51} later extended the technology acceptance model to explain perceived usefulness and usage intentions and replaced the theory of reasoned action with the more recent the theory of planned behaviour. The extended model was tested in both voluntary and mandatory settings, strongly supporting the extended model\textsuperscript{89}. In an attempt to integrate the main competing user acceptance models, Venkatesh et al.\textsuperscript{92} later formulated the unified theory of acceptance and use of technology. This model was found to outperform all individual models.

**Convergence of communication and behaviour**

Even though the two traditions have different starting points, effectiveness based on communication theory and user satisfaction based on social psychology both have merits. It certainly seems odd to equate satisfaction with success of an information system because it fails to cover the task for which the system is designed to improve. However, user satisfaction is a fundamental component of success by proxy, because it is hard to imagine satisfaction with a system that fails to deliver, and perceived usefulness and ease of use are sensible measurements of user satisfaction (Table 5).
Table 5. Two tradition of information system evaluation

<table>
<thead>
<tr>
<th>Tradition</th>
<th>System success</th>
<th>User behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Information system success</td>
<td>Technology acceptance model</td>
</tr>
<tr>
<td>Area</td>
<td>Communication</td>
<td>Behaviour</td>
</tr>
<tr>
<td>Theoretical framework</td>
<td>information influence theory</td>
<td>theory of planned behaviour</td>
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<tr>
<td>Focus</td>
<td>Effectiveness</td>
<td>Usage</td>
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<tr>
<td>Activity</td>
<td>Information system design</td>
<td>Interaction design</td>
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</tbody>
</table>

Both traditions have been criticized, but they have been evaluated, adjusted and refined more than any other model of information system usage and success. A modern synthesis for design and evaluation of information system success and usage can be said to rest on two traditions that complement each other in terms of understanding the use and benefit of information systems (Figure 4).

Figure 4. Author interpretation of the development of two converging traditions. Lines denote developmental directions and dashed lines denote shared concepts and theories.
The overall aim of this study was to design, implement, and formatively evaluate tools for use in a community-based health promoting intervention for adolescents.

**SPECIFIC AIMS OF STUDIES**

- To determine whether estimating body mass using only weight and height data is associated with the corresponding estimate at the age of 15 years (Study I).

- To use epidemiological data and a standardized economic model to compare projected costs for obesity prevention in late adolescence accrued using a cross-sectional weight classification for selecting adolescents at age 15 years compared with a longitudinal classification (Study II).

- To examine what aspects of the structure and functions of an online health promoting community are critical to satisfy the needs of the user community and public health goals and service capabilities (Study III).

- To develop a checklist for a pre-launch evaluation of online health promoting communities. The checklist is required to take the perspectives of both the user community and the health services into account (Study IV).
Public health intervention can be said to follow five fundamental steps\textsuperscript{34}. Following this general outline, the aim of the project described in this thesis is to design an intervention, but the foundations of this work were already in place from previous efforts, and there is still work to be done in the future (Table 6).

Table 6. Stages of community organization in public health interventions\textsuperscript{34}

<table>
<thead>
<tr>
<th>Community organization</th>
<th>Thesis outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Community analysis</td>
<td>Previous research and Studies I–III</td>
</tr>
<tr>
<td>2 Design and initiation</td>
<td>Study III</td>
</tr>
<tr>
<td>3 Implementation</td>
<td>Studies III and IV</td>
</tr>
<tr>
<td>4 Programme maintenance - consolidation</td>
<td>Future directions: intervention evaluation</td>
</tr>
<tr>
<td>5 Dissemination and reassessment</td>
<td>Future: scientific reports and marketing</td>
</tr>
</tbody>
</table>

All four studies are focused on a cohort in the south east of Sweden born around 1990, however the surveillance of this group began well before this thesis project\textsuperscript{95–97}. The first two studies in this thesis use data from the first 15 years of the 1991 cohort living in Östergötland to determine the predictability of obesity from childhood BMI and to investigate interventions and available evidence to suggest appropriate obesity prevention. The next two studies use these findings to design (Study III) and formatively evaluate (Study IV) a health promotion intervention suggested by Study II (Table 7).
Methods

Table 7. The four studies of the thesis

<table>
<thead>
<tr>
<th>Method</th>
<th>Study I</th>
<th>Study II</th>
<th>Study III</th>
<th>Study IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td>All children born in 1991 participated in regular measurements of weight and height at well-child health centres and school health care assessments in Östergötland County</td>
<td>Convenience sample of adolescents born around 1991 from three municipalities in the south east of Sweden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>Longitudinal epidemiological data</td>
<td>Weight classification trajectories</td>
<td>Focus groups and participatory design processes</td>
<td>The development of an online health promoting community</td>
</tr>
<tr>
<td>Result</td>
<td>Timing of interventions based on saturation of weight classification</td>
<td>Projection of cost for obesity prevention in late adolescence</td>
<td>An online health promotion community</td>
<td>Checklist for online health promoting communities</td>
</tr>
</tbody>
</table>

STUDIES I AND II

The study cohort includes all children who participated in regular measurements of weight and height at well-child health centres and school health care assessments in Östergötland. Children for whom complete measurements were available at all seven time points were included in Study I, and all children for whom complete measurements at age 5, 10 and 15 years were available were included in Study II (Figure 5).
Data collection

Data on weight and height were gathered from the children’s well-child health centre records at birth and at age 1.5 years, 2.5 years and 5 years. Thereafter, weight and height data were gathered from the school health service records at 7, 10 and 15 years of age. At the 72 senior level schools in the county, the registration of weight and height took place either in grade 8 or 9 (at age 14–15 years).

In Study II, the children for whom complete measurements at age 5, 10 and 15 years were available were categorized into cross-sectional weight classes and longitudinal weight trajectory groups when they were 15 years of age. The cross-sectional and trajectory-based selection strategies for different interventions were compared using the cost of service as the end point measure.

For administrative reasons, schools in the county recorded weight and height at different semesters, which influenced the exact measurement age (Table 8).
Methods

Reasons for missing data included incomplete health records, children moving out of the county in their first 15 years, individuals declining to participate, individuals with physical or mental disorders excluded by choice of their school, and individuals with protected identity.

Table 8. Study cohort for Studies I and II

<table>
<thead>
<tr>
<th>Study II</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>10</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>5.2</td>
<td>10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>n</td>
<td>2059</td>
<td>2253</td>
<td>2059</td>
<td>2253</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study I</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>2.5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Median</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>7.3</td>
<td>7.3</td>
<td>10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>n</td>
<td>1718</td>
<td>1861</td>
<td>1718</td>
<td>1861</td>
</tr>
</tbody>
</table>

Data analysis

The ponderal index (PI) was used as the measure of body mass for each child and set of measurements from birth to 1.5 years of age. The BMI was calculated from 2.5 to 15 years. Overweight and obesity were defined according to the recommendations of the International Obesity Task Force. From 2.5 years of age, the BMI values were also categorized into age- and gender-adjusted classes.

Correlations between the BMI recorded from birth to age 10 (at age 0, 1.5, 2.5, 5, 7, and 10 years) and the BMI at 15 years of age were computed pairwise. Measurements of BMI, weight and height within the same subject are prone to be correlated to some degree. To determine when this progression exhibited saturation, statistical tests were performed using as the null hypothesis that the correlation (r) between the measurements at specific ages and the corresponding measurement at age 15 years was equal or less than limit values suggested by the Cohen Scale. This scale denotes a correlation of 0.5–1.0 as
large/strong, a correlation of 0.3–0.5 as moderate and a correlation of 0.1–0.3 as small.

The cross-sectional selection strategy in Study II was based on the organizational routines in the study county at the time of the final data collection (2006–2007). The alternative trajectory-based selection strategy was combined with weight-history sensitive interventions at four levels according to the estimated risk for persistent obesity.

The children were classified into one of 9 trajectory groups according to their history of weight classifications, and each trajectory was allocated to a program level.

**STUDY III**

In Study II, the matching of obesity epidemiology with available interventions in the region, situated in the south east of Sweden, indicated that the demand for obesity prevention among adolescents was greater than the resources available. Our projections indicated that obese adolescents would benefit from more specialized interventions, but that there was also a need for an online public health intervention.

Qualitative data from adolescents on health appraisals and perspectives on health information were collected in a Swedish health service region. Using a three-step analysis, the data were transformed to specify the structure and functions of an online health promoting community intervention (Figure 6). In the first step, the crude data were analysed and structured into health information needs. The identified needs were then transformed into requirements for an online health promoting community intervention by an interdisciplinary expert team. In this context, needs refer to problems expressed that warrant a solution; requirements are associated with the design of an information system. In the third step, a prototype based on the user-derived requirements was compared with regional public health goals and service capabilities by public health official representatives from the region, and modified accordingly.
Data collection

The model population for the development of the online health promoting community intervention consisted of high school students in their senior year. For the design, a convenience sample (n=65) representing the population of adolescents aged 15–20 years (n≈50 000) in the study region was used. Qualitative data were collected using two sets of focus group interviews. The topics for the first set of interviews were physical health, psychological health, and health products; the second set of interviews covered health information in the media, information needs and information-seeking behaviour. The protocol for the focus group sessions is provided in Additional file 1 of Study III. Focus group interview sessions were arranged with adolescents according to two criteria: home community sociocultural profile (industrial–technological, small business–church dominated, small business–agricultural)
and high school program profile (high school program in science, arts or nursing). High schools corresponding to the listed program profiles in each study community were contacted and asked for assistance with recruiting students for focus group meetings. Initially, each student was asked to participate in both focus groups but some cancellations occurred and stand-ins were accepted. Of the 65 participating adolescents, 48 participated in both sets of focus group interviews, 12 only in the first, and 5 only in the second. In total 18 focus group sessions took place.

Data from the focus groups were collected over a 2-month period in 2010. The focus groups were video recorded and lasted for approximately 90 minutes for the first occasion and 60 minutes for the second. In total, approximately 20 hours of video were collected. Two moderators were present at each focus group: one moderating the discussion and the other making observations. The data were collected by means of formal natural group discussion defined as a group interview with invited people who already know each other. The resulting requirements and various prototypes were demonstrated and discussed with representatives from regional public health services in meetings and telephone conferences.

**Data analysis**

**Needs**

An analysis of health information exchange needs was performed using data from the focus group meetings. Summaries from each focus group were compiled as transcripts from the video recordings by one of the moderators and sent to the second moderator of the focus group to make sure that the summary was accurate. The transcribed content was coded based on themes identified in the material by the first moderator.

Statements from the focus groups related to health information exchange were identified and a summative content analysis of these units was performed to identify specific user needs as related to an information system. In addition, statements regarding content and topics of interest were used to assist in drafting the content for the information system.
Requirements

A process to determine the user-derived system requirements was undertaken based on the principles of design space analysis\textsuperscript{100,101} with design rationales captured using an informal representation\textsuperscript{102}. A design team consisting of two computer scientists, an interaction designer, and a cognitive scientist drafted the requirements for an online health promoting community based on the health information exchange needs identified. The design decisions were then constructed into a composite design rationale. A design rationale is an explicit list of decisions made during a design process, and the reasons why those decisions were made\textsuperscript{103}. The design rationale primarily consisted of the identified user needs, the user-derived requirements, technical and organizational system solutions, alternative solutions, and the reason for their rejection when applicable. The design rationale was also presented as a prototype online health promoting community.

Policy goals and service capability

In the final step, the design rationale document and prototype were presented to a panel of public health professionals representing the health service providers in the region. The task presented to the panel was to assess the prototype with regard to the regional public health goals and service capability for an online health promoting intervention. Design solutions were reviewed in sessions at which the expected positive and negative consequences of each design solution were examined in light of its hypothetical implementation in the study setting. When conflicts between requirements, public health goals, and service capabilities were found, the solutions were adjusted in order to neutralize the conflicts. These adaptations were compiled, analysed for common features, and documented.

Study IV

Study IV was based on an action research design. Action research balances problem-solving actions implemented in a context with analysis to understand underlying causes\textsuperscript{104}. In Study IV, the researchers participated as agents in the development process and as observers of the same process. A prototype
checklist was developed from the literature on information system success and applied for formative evaluation in a case study implementation of an online health promoting community. The problem-solving actions in this process were documented and analysed using qualitative methods.

**Case study setting**

The county in this case study (total population 420 000) is situated in the south east of Sweden. To counteract the development of obesity among young adults, a need for health promotion among this age group was identified in the health policy for the county in Study II. On this initiative, public health practitioners and researchers set out to develop a public health intervention aimed at adolescents. A needs analysis was performed using data from focus group interviews with adolescents in the region moderated by a researcher together with one local public health representative. Following a requirements analysis performed by an interdisciplinary expert team consisting of two computer scientists, an interaction designer, and a cognitive scientist and involving a sample of young adults, a prototype online health promoting community was drafted using the website content management system Joomla! (http://www.joomla.org). The resulting online health promoting community design was demonstrated and discussed in meetings and telephone conferences with representatives from regional public health services, public health researchers and senior public health officials, and adjusted accordingly.

**Data collection**

Constructs used in the evaluations of information system success were used as the basis for the formation of a prototype online health promoting community evaluation checklist. The criteria for concepts to be included in the checklist were that they were applicable for evaluation of information system success and available for application before the introduction of the online health promoting community to the end users. A seminal overview article of the information system success framework and research into information system success was used as the starting point for assessment of relevant constructs. An initial set of constructs was established from available and validated evaluation instruments such as the SERVQUAL instrument, Mirani and
Methods

Lederer’s instrument\textsuperscript{107}, the adaptation by Martinsons et al.\textsuperscript{108} of the Balanced Scorecard\textsuperscript{109}, and Torkzadeh and Dolls’ instrument for measuring the individual impact of information systems\textsuperscript{110}, as well as others\textsuperscript{111–115}. Six preliminary constructs applicable to the success of online health promoting communities were identified.

Formative evaluation data were collected from a process whereby an adjusted checklist version was applied to evaluate the online health promoting community in the case study. The online health promoting community, not yet introduced to its end users, was assessed by the researchers using each construct in the checklist. The assessment data were collected from the online health promoting community requirements and design specifications, field notes made during meetings with the online health promoting community development team, and feedback reports from invited users. The specifications were represented as design rationales whereby the identified user needs were connected to alternative online health promoting community design solutions and the rationale behind the design choices made during the implementation, including why alternative solutions were rejected.

Data analysis

In the first step, constructs were excluded from the baseline checklist based on the inclusion criteria for the checklist. In the second step, the remaining constructs were adapted to the online health promoting community context, forming the study checklist for the formative evaluation. The reasons for each construct adaptation were recorded by the researchers.

In the third step of the analysis, the data from the formative evaluation of the checklist were categorized and interpreted by the researchers. The data were first categorized by the author, and the interpretations thereafter established by the other two authors of Study IV. Disagreements were resolved by discussions involving all authors. In the final step, the researchers consolidated their analysis with the regional public health representatives.
RESULTS

STUDY I

The aim of Study I was to determine whether estimating body mass using only weight and height data is associated with the corresponding estimate at the age of 15 years.

Prevalence of overweight and obesity

From the 5778 children born in 1991 still resident in the county in 2007, 3579 (62%) provided complete data from birth to 15 years of age; 1718 (48%) were girls and 1861 (52%) were boys.

At the age of 15 years, fewer girls (2.6%; 95% confidence interval (CI) 1.9–3.3%) than boys (4.6%; 95% CI 3.7–5.5%) were obese but there was no statistically significant difference in the prevalence of being overweight between boys and girls at 15 years of age (12.9% for girls and 14.1% for boys). For both girls and boys, the prevalence of overweight increased from age 7 to 10 years and then decreased from 10 to 15 years of age (Figure 7).
Correlations between growth characteristics

The correlation between PI/BMI measurements and BMI at 15 years of age was strong (significantly higher than $r = 0.5$) from 5 years of age (Figure 8). Reviewing the individual data, 23% of the girls and 8% of the boys classified as obese at 5 years of age were found to be normal weight at the age of 15 years. Only 6% of those who were obese at 5 years of age among both sexes were of normal weight at the age of 10 years.
Results

Figure 8. Correlations between point estimates of PI/BMI at different ages with BMI at 15 years of age.

STUDY II

The aim of Study II was to use epidemiological data and a standardized economic model to compare projected costs for obesity prevention in late adolescence accrued using a cross-sectional weight classification for selecting adolescents at age 15 years compared with a longitudinal classification.

Cross-sectional and trajectory-based classifications

At age 15 years, the study cohort comprised 82.3% normal weight adolescents, 13.8% overweight individuals and 3.8% obese adolescents. Of the 9 weight trajectories, each trajectory had at least 7 children represented in the 1991 cohort (Table 9).

74.9% of the children were consistently classified as normal weight at age 10 and 15 years, 8.3% of the children were classified as overweight at age 10 and 15 years, and 2.4% of the children were consistently classified as obese at age 10 and 15 years. 4.1% of the children moved from being normal weight to overweight during the period and 1.4% moved from being non-obese to being obese.
Table 9. Weight trajectories according to IOTF BMI category at ages 10 and 15 years for children born in 1991 in Östergötland County (n=4312) displayed by estimated risk levels for persistent obesity

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Weight classification</th>
<th>Age ~10 years</th>
<th>Age ~15 years</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I</td>
<td>Obese</td>
<td>Obese</td>
<td>104</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>Level II</td>
<td>Normal</td>
<td>Obese</td>
<td>7</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>Obese</td>
<td>55</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Level III</td>
<td>Normal</td>
<td>Overweight</td>
<td>179</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>Overweight</td>
<td>357</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obese</td>
<td>Overweight</td>
<td>60</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obese</td>
<td>Normal</td>
<td>8</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Level IV</td>
<td>Normal</td>
<td>Normal</td>
<td>3230</td>
<td>74.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>Normal</td>
<td>312</td>
<td>7.2</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of selection strategies

Using the cross-sectional selection strategy, 96.2% of adolescents at age 15 years were provided with population-based obesity interventions, and 3.8% were eligible for evaluation by a paediatric specialist. The total annual cost for the program based on the selection strategy was estimated to be USD 463 581 per 1000 adolescents.

Figure 9. Trajectory-based program.

In the trajectory-based program, 82.1% of adolescents at age 15 years were provided with population-based obesity interventions, and an additional 15.4% of the adolescents were provided with individual interventions using the Internet (14.0%) or in primary care (1.4%). 2.4% of the adolescents were
eligible for intensive paediatric care. Weight trajectories for each group in the trajectory-based intervention program for the adolescents are shown in Figure 9. The total annual cost of the program based on the selection strategy was estimated to be USD 302,016 per 1000 adolescents (Table 10).

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Trajectory-based program</th>
<th>Cross-sectional program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I</td>
<td>Paediatric evaluation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1896 (1/3)</td>
<td>65 728</td>
<td>1896 (1/3)</td>
</tr>
<tr>
<td>1935 (1/3)</td>
<td>67 080</td>
<td>1935 (1/3)</td>
</tr>
<tr>
<td>31 553 (1/3)</td>
<td>1 093 837</td>
<td>31 553 (1/3)</td>
</tr>
<tr>
<td>Total</td>
<td>1 226 645</td>
<td>1 226 645</td>
</tr>
<tr>
<td>Level II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1896 (1/3)</td>
<td>39 184</td>
<td></td>
</tr>
<tr>
<td>1935 (1/3)</td>
<td>39 990</td>
<td></td>
</tr>
<tr>
<td>31 533 (1/3)</td>
<td>651 682</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11 552</td>
<td>730 856</td>
</tr>
<tr>
<td>Level III</td>
<td>Population-based intervention</td>
<td></td>
</tr>
<tr>
<td>Wake-up</td>
<td>179 (4.2)</td>
<td>10 (35 626)</td>
</tr>
<tr>
<td>Check-up</td>
<td>357 (8.3)</td>
<td>10 (16 065)</td>
</tr>
<tr>
<td>Support</td>
<td>60 (1.4)</td>
<td>10 (6265)</td>
</tr>
<tr>
<td>Total</td>
<td>596 (13.8)</td>
<td>28 595</td>
</tr>
<tr>
<td>Level IV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 3550 (82.3)</td>
<td>10 (35 500)</td>
<td>10 (35 500)</td>
</tr>
<tr>
<td>Total program 4312 (100)</td>
<td>1 302 292</td>
<td>1 998 961</td>
</tr>
<tr>
<td>Cost per 1000 children 302 016</td>
<td>463 581</td>
<td></td>
</tr>
</tbody>
</table>

*USD

**STUDY III**

The aim of this study was to examine what aspects of the structure and functions of an online health promoting community are critical to satisfy the needs of the user community and public health goals and service capabilities.
Results

Needs

The focus group transcript was divided into 505 statement units related to health information exchange. These units were classified into ten categories of user health information exchange needs (Table 11); content-related needs were excluded. The most prominent content-related statements were about food, exercise and well-being.
Table 11. User health information exchange needs

<table>
<thead>
<tr>
<th>Focus group context</th>
<th>User health information exchange need</th>
</tr>
</thead>
<tbody>
<tr>
<td>The adolescents exhibited impressive knowledge and had no shortage of simple</td>
<td>The experience should be educational</td>
</tr>
<tr>
<td>health advice; they rather challenged traditional tenets of diet and exercise, not</td>
<td></td>
</tr>
<tr>
<td>because they distrusted health advice, but because they distrusted everything.</td>
<td></td>
</tr>
<tr>
<td>They did not lack information, but rather a method to discern the true from the</td>
<td></td>
</tr>
<tr>
<td>false. Since almost everything health-related they know of is presented with the</td>
<td></td>
</tr>
<tr>
<td>agenda of selling them a product, their rule of thumb was to generally disregard</td>
<td></td>
</tr>
<tr>
<td>everything</td>
<td></td>
</tr>
<tr>
<td>Even though the adolescents disregarded information provided by health care</td>
<td></td>
</tr>
<tr>
<td>organizations, they did believe that physicians and nurses could provide</td>
<td></td>
</tr>
<tr>
<td>genuine useful advice. However, they also wanted a personal comment</td>
<td></td>
</tr>
<tr>
<td>regarding their questions, not general advice addressing everyone</td>
<td></td>
</tr>
<tr>
<td>Exploring subjects and seeing the point of view of others in discussion forums</td>
<td>Discussions in which experts participate</td>
</tr>
<tr>
<td>and boards was both appreciated and utilized among the adolescents; however, they</td>
<td></td>
</tr>
<tr>
<td>had experienced saturation where the discussion was halted either because</td>
<td></td>
</tr>
<tr>
<td>of lack of experts with more knowledge to inject into the discussion, or where a</td>
<td></td>
</tr>
<tr>
<td>debate turned sour ending without any means to verify or check the validity of</td>
<td></td>
</tr>
<tr>
<td>the claims given by either party</td>
<td></td>
</tr>
<tr>
<td>The adolescents belong to a generation where most of their information sources</td>
<td>Easy accessible content</td>
</tr>
<tr>
<td>are online and funded by ads, and where additional pages, reloads, and links</td>
<td></td>
</tr>
<tr>
<td>increase the revenue of the website. It therefore was reported to be both a</td>
<td></td>
</tr>
<tr>
<td>tedious and confusing task to access the content sought after</td>
<td></td>
</tr>
<tr>
<td>Most health-related information provided online was reported to be both</td>
<td>Information about our interests</td>
</tr>
<tr>
<td>abstract and general, or specific but provided to sell products. This included</td>
<td></td>
</tr>
<tr>
<td>information from governmental sources and information from health care providers.</td>
<td></td>
</tr>
<tr>
<td>They reported a lack of information regarding the subjects they cared about and</td>
<td></td>
</tr>
<tr>
<td>wanted to know more about</td>
<td></td>
</tr>
<tr>
<td>Reading about faulty but widely held beliefs was seen as entertaining and</td>
<td>Dismantling of myths and misconceptions</td>
</tr>
<tr>
<td>informative, and the adolescents were fully aware that commercial interests</td>
<td></td>
</tr>
<tr>
<td>both skewed the facts to push products, and outright lied if they could get away</td>
<td></td>
</tr>
<tr>
<td>with it. Having health professionals call this out was reported to be an exciting</td>
<td></td>
</tr>
<tr>
<td>prospect</td>
<td></td>
</tr>
<tr>
<td>Diets and types of exercise were topics that were seen as very difficult to find</td>
<td>Be able to share tips and experiences</td>
</tr>
<tr>
<td>useful information. Information from commercial interests was entirely</td>
<td></td>
</tr>
<tr>
<td>distrusted, and since both diet and types of exercise are not only a comparison</td>
<td></td>
</tr>
<tr>
<td>of efficiency, but also experience, sharing experiences among themselves was</td>
<td></td>
</tr>
<tr>
<td>seen as valuable</td>
<td></td>
</tr>
<tr>
<td>The aesthetics of websites was reported to be used as a tool to determine the</td>
<td>Professional and serious</td>
</tr>
<tr>
<td>underlying agenda, trustworthiness, and target group of the website. In this</td>
<td></td>
</tr>
<tr>
<td>process, very attractive sites could be immediately dismissed because it was</td>
<td></td>
</tr>
<tr>
<td>apparent that such sites were drafted to push products. A clean, simple, professional site with a clear manifesto and clear agenda was seen as important for credibility among the adolescents</td>
<td></td>
</tr>
</tbody>
</table>
Results

One critique of communication from the scientific community and health care providers was its reliance on a wall of text. Adolescents are sometimes accused of lacking attention span and in need of simple accessible short bursts of information. However, the adolescents reported that they were so overwhelmed by information that it has become necessary to be able to use heuristics to determine gold from grit. There was no aversion to in-depth information; rather there is a need to have very concise and simple introductions.

Even good communities were reported to be shunned because of bad manners and uncivil conduct. Moreover, it was emphasized that once a community gets a certain vibe, it sticks forever.

<table>
<thead>
<tr>
<th>Concise presentation</th>
<th>Maintain a civil discourse</th>
</tr>
</thead>
</table>

Requirements

The structures and functions identified as requirements to satisfy the adolescents’ health information exchange needs included both technical and organizational components. A composite design rationale for the online health promoting community was completed by linking the identified user needs, user-derived requirements, and technical and organizational system solutions. When applicable, alternative solutions and the reason for their rejection were also listed (Table 12).
### Table 12. Reconstructed design rationales.

<table>
<thead>
<tr>
<th>Adolescent user need</th>
<th>Adolescent user-derived requirement</th>
<th>Design solution</th>
<th>Alternative solutions and reasons for rejection</th>
</tr>
</thead>
<tbody>
<tr>
<td>The experience should be educational</td>
<td>The intervention must be able to facilitate self-directed learning</td>
<td>Online discussion forum where the system aids in keeping track of new posts in areas of interest, requiring user registration and a user management system</td>
<td>Text/video chat, wiki, podcasts/vodcasts, and blogs all violated a combination of other needs such as professional and serious, concise presentation and civil discourse</td>
</tr>
<tr>
<td>Personal advice from health professionals</td>
<td>Participation by health professionals who can be accessed</td>
<td>An online system for presenting experts and the ability to ask and get answers from experts</td>
<td>An expert panel representing the key public health areas available for regular questioning</td>
</tr>
<tr>
<td>Discussions in which experts participate</td>
<td>Active participation by experts in a forum</td>
<td>An online discussion forum. Distinguishable user groups with different levels of authority</td>
<td>An expert panel who are willing to publicly engage in online discussions</td>
</tr>
<tr>
<td>Information about our interests</td>
<td>User-driven content</td>
<td>Reasonably accessible and permanent record of online discussions</td>
<td>A chat setup would satisfy this requirement, however there is less opportunity to satisfy the need for public civil discourse, and the need to exchange tips and experiences would be severely hampered</td>
</tr>
<tr>
<td>Easily accessible content</td>
<td>Simple categorical organization and presentation of content</td>
<td>Organization and presentation of content into a minimal set of categories. Content management system for categorization and presentation</td>
<td>–</td>
</tr>
<tr>
<td>Dismantling of myths and misconceptions</td>
<td>Provide commentary on prevalent myths and misconceptions</td>
<td>Provision of intuitive methods for production of editorial material</td>
<td>Provision of editorial content by health care professionals based on current events and health-related media reports</td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Feature</th>
<th>System Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be able to share tips and experiences</td>
<td>Provide means for users to post content</td>
<td>An online forum with registered user ID with suitable categories. A user registration and management system</td>
<td>User blogs. The interest in blogging was assessed to be low, and problems of regulating what was off-topic made this undesirable</td>
</tr>
<tr>
<td>Professional and serious</td>
<td>A clean and minimalistic layout free from commercial interests</td>
<td>A content management system without ads. Design of an appropriate layout</td>
<td>Maintenance of active communities without a content management system is prone to errors and mistakes in updates and layouts. A free and simple content management system with extensive community support dramatically reduces the load of maintenance</td>
</tr>
<tr>
<td>Concise presentation</td>
<td>Conform content to blogesque (short and sweet) format</td>
<td>A system to post videos and organize short articles</td>
<td>Editorial work on content; however, the work load involved was deemed to be high</td>
</tr>
<tr>
<td>Maintain a civil discourse</td>
<td>Vigilant moderation</td>
<td>Provide means for moderation of discussions</td>
<td>Enough moderators to keep up with online activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Use of strict rules of conduct to educate users was discussed, but there will always be abuse online</td>
</tr>
</tbody>
</table>
Public health goals and service capabilities

The assessment of the design rationale document and prototype in light of the regional public health goals and service capabilities raised concerns about organizational aspects of the design solutions. No technical aspects of the design solution were found to be problematic. In brief, compromises were needed to resolve conflicts involving the management of organizational resources and responsibilities.

Two conflicts arose about making a health panel available for questions from adolescents and engaging practitioners in online discussions to meet the adolescents’ needs (personal advice from health professionals and discussions in which experts participate). With regard to the resources at hand, monitoring the potentially vast number of questions and discussions was deemed to be too high a workload for the practitioners. The compromise found was to use a previously rejected design solution of using vodcasts. To produce the vodcasts, it was decided to appoint a community manager to monitor the discussion, collect questions and hot topics, and regularly interview the practitioners. A similar problem occurred when the practitioners were expected to produce editorial content as comments on current health-related events and media reports to meet the need for dismantling of myths and misconceptions. Because of the need for special care when producing material for the public from health services, these editorials were deemed to demand too much work. The compromise found was to transfer this responsibility to public health academics because they are more familiar with producing editorial material, and public communications from them would not be seen to come from the regional health service.

The fourth conflict was on the choice of online health promoting community editorial content based on monitoring of online discussions in order to meet the adolescents’ need for information about our interests. It was speculated that the editorial content would then be focused exclusively on topics with low priority in public health policies, e.g. make-up and skincare products. However, the practitioners were sympathetic to an approach to adapt the editorial content to adolescents’ interests and a compromise was decided whereby monitoring was to be accompanied by a clear statement of the purpose and focus of the online health promoting community.
Results

The fifth conflict was about the moderators keeping up with the online activity if the online health promoting community intervention was used extensively, regarding the need to maintain a civil discourse. The compromise agreed on involved recruiting moderators from members of the adolescent user community based on exemplary conduct.

STUDY IV

The aim of Study IV was to develop a checklist for a pre-launch evaluation of online health promoting communities. The checklist is to take into account both the user community and health service perspectives.

The adjusted checklist for pre-launch evaluation of online health promoting communities included the following constructs: information quality, service quality and subjective norms (Table 13).

Table 13. Online health promoting community evaluation constructs

<table>
<thead>
<tr>
<th>Construct - definition</th>
<th>Construct evaluation questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information quality: Degree to which information produced by the online health promoting community has attributes of content, accuracy, and format required by the users(^1)(^4)</td>
<td>The site provides…</td>
</tr>
<tr>
<td></td>
<td>…output that is exactly what you need</td>
</tr>
<tr>
<td></td>
<td>…accurate information</td>
</tr>
<tr>
<td></td>
<td>…information that is useful</td>
</tr>
<tr>
<td>Service quality: Degree to which users’ perceived and expected service align(^1)(^5)</td>
<td>Online health promoting community staff give prompt service to users</td>
</tr>
<tr>
<td></td>
<td>Online health promoting community staff have the knowledge to do their job well</td>
</tr>
<tr>
<td></td>
<td>Online health promoting community has users’ best interest at heart</td>
</tr>
<tr>
<td>Subjective norms: Degree to which individuals perceive that others believe they should use the website(^1)(^4)</td>
<td>People who influence my behaviour think I should use the site</td>
</tr>
<tr>
<td></td>
<td>People who are important to me think I should use the site</td>
</tr>
<tr>
<td></td>
<td>I use the site because of the number of people I know use it</td>
</tr>
</tbody>
</table>

In the following, each construct and its formative evaluation are reported in the form of the definition of the construct, contextual adaptation of the construct, formative evaluation in the case study project, and finally the
constructed checklist applicable to both the end-user community and the health care services. After using the preliminary checklist, some changes in terms of the actual online health promoting community and in terms of routines for the editorial work with the online health promoting community were made (Tables 15–17). The application of the checklist to the study online health promoting community is provided in Additional file 1 of Paper III.

**Information quality**

**Construct definition:** Information quality is defined as the degree to which information produced by the website has the attributes of content, accuracy, and format required by the users.

**Contextual adaptation of the construct:** Information quality indicates that the information is relevant and needed by the users with respect to content, accuracy and format. The content is mainly decided on from the needs of the users, but this has to be balanced by the purpose of the online health promoting community from the health service standpoint. Perception of trustworthiness is important for users, but quality assurance is a more pressing priority for the health service. The contextual adaptation of the construct resulted in check points for (1) content area, that the website was about the right subject area; (2) trust, that the method of developing content was sound and clearly communicated to the users; and (3) format, that the content was presented in a way expected by the end users.

**Formative evaluation in the case study project:** One concern was that the commitment of the health service to information quality was contingent on the funding from a research project. For the project to be adapted for routine practice, the health benefit of the online health promoting community needs to be demonstrated. The consequence of the health service withdrawing their commitment is a concern, and is one of the reasons why research projects of this nature are difficult to carry out responsibly. There is no guarantee for the user of the website that the service is reliable, which is an important factor for information system success.
Table 14. Information quality checklist

<table>
<thead>
<tr>
<th>Information quality</th>
<th>End-user community</th>
<th>Health services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content area</td>
<td>Is the content (subject areas and framing) of the online health promoting community in sync with the needs of the users?</td>
<td>Is the content (subject areas) of the online health promoting community in sync with the intent of the health service?</td>
</tr>
<tr>
<td></td>
<td>Is the framing of the content in sync with the preferences of the users?</td>
<td>Is the framing of the content in sync with the intent of the health service?</td>
</tr>
<tr>
<td>Trust</td>
<td>Is it possible for the users to assess the accuracy of the content?</td>
<td>Is there a method for quality assurance of the content?</td>
</tr>
<tr>
<td></td>
<td>Is the source of the content clearly communicated?</td>
<td>Is there an established guideline to resolve misinformation and conflicting information?</td>
</tr>
<tr>
<td></td>
<td>Is it possible to challenge the accuracy of the information?</td>
<td>Is the responsibility for the accuracy of the information clear?</td>
</tr>
<tr>
<td></td>
<td>Is there a clear distinction between user-generated content and authorized content?</td>
<td>Is it clear by what authority, or role, content is provided from the health service?</td>
</tr>
<tr>
<td></td>
<td>Is there an established method for filtering relevant content?</td>
<td>Is it possible to overview the extent of discussions, commentaries and remarks about content?</td>
</tr>
<tr>
<td>Format</td>
<td>Is the content presented in formats that are in sync with the user preferences?</td>
<td>Is the format for the content suitable for the content provider to work with?</td>
</tr>
</tbody>
</table>

Service quality

**Construct definition:** Service quality is defined as the degree of alignment between users’ expected and perceived service experiences\(^\text{115}\).

**Contextual adaptation of the construct:** User preferences of service quality are not uniform, and for the health service, it is important to have sustainable funding and personnel for the management of the website. The contextual adaptation of the construct resulted in check points for (1) staff competence, e.g. that the staff were qualified for the task, and that this was properly communicated; (2) prompt service, that the health service had the capacity to manage the online activity; and (3) empathy, that the staffs’ activities online were unbiased and honest, and that this was communicated properly.

**Formative evaluation in the case study project:** A concern was raised regarding having moderators from the community working voluntarily in the
online health promoting community. It is not reasonable to demand professionalism from voluntary moderators and it was found that the situation needs to be monitored closely in supervisory meetings.

Table 15. Service quality heuristic design evaluation

<table>
<thead>
<tr>
<th>Service quality</th>
<th>End-user community</th>
<th>Health services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff competence</td>
<td>Are the rules for the staff transparent?</td>
<td>Are the rules of the staff reasonable and sustainable?</td>
</tr>
<tr>
<td></td>
<td>Are the responsibilities of the staff clearly communicated?</td>
<td>Is the website suitable to facilitate the expertise of the staff</td>
</tr>
<tr>
<td>Prompt service</td>
<td>Are the tasks of the staff clearly communicated</td>
<td>Are the tasks of the staff reasonable and sustainable?</td>
</tr>
<tr>
<td>Empathy</td>
<td>Is the agenda for the staff and website clearly communicated</td>
<td>Is the agenda of the staff and website unbiased and honest?</td>
</tr>
</tbody>
</table>

**Subjective norms**

**Construct definition:** Subjective norms is defined as the degree to which individuals perceive that others believe they should use the website.  

**Contextual adaptation of the construct:** Subjective norms are the effect on use that comes from networking offline and online, and, as a prerequisite, the online health promoting community needs be able to facilitate social connectivity. The contextual adaptation of the construct resulted in check points for (1) social facilitation, where users and the corresponding staff are tied together by some special interest, organization or region; (2) interconnectivity, whereby the site is social media friendly, and problems are not introduced when content is moved outside the online health promoting community; and (3) communication, whereby users and staff are not hindered in their communication with each other, but communication is also manageable.

**Formative evaluation in the case study project:** An issue was identified regarding what happens to statements made by health professionals when shared in a new context over social media. In the world of social media, it is impossible to monitor how content is presented, framed, and used; subsequent exchange may lead to misinformation being presented unchallenged. Also outdated or faulty information corrected in the community is not necessarily similarly updated on third party social platforms. In addition, the website staff have no authority to act in situations when users are clearly in need of health
care; and there was a lack of preparedness for how to assess serious health issues online.

Table 16. Subjective norms heuristic design evaluation

<table>
<thead>
<tr>
<th>Subjective norms</th>
<th>End-user community</th>
<th>Health services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social facilitation</td>
<td>Is the online health promoting community tied to a geographic area or organization?</td>
<td>Are the online health promoting community staff tied to a region, organization, or adequate profession?</td>
</tr>
<tr>
<td>Interconnectivity</td>
<td>Is there functionality to connect content and interaction with other social media?</td>
<td>Are there any issues with content being shared over social media?</td>
</tr>
<tr>
<td>Communication</td>
<td>Is it possible to interact with other users privately and publicly?</td>
<td>Is there functionality to connect with individual users, for referral or moderation?</td>
</tr>
<tr>
<td></td>
<td>Is there functionality to connect with the staff, for questions or private messaging?</td>
<td>Is there authority to connect with individual users, for referral or moderation?</td>
</tr>
</tbody>
</table>
DISCUSSION

The overall aim of this thesis was to design, implement, and formatively evaluate tools for use in a community-based health promoting intervention for adolescents. To determine the requirements for the community-based intervention, the target population was assessed to determine the health-related needs and the current and evidence-based interventions available. In this assessment, we observed a need among adolescents for a community-based initiative, facilitating honest and unfiltered dialogue on health between health professionals and young people. To determine the requirements for an online health promoting community to meet this need, we initiated a participatory design project together with regional public health services and adolescents in the region. In the design of the online health promoting community, conflicts involving the management of resources and responsibilities in the public health organization were identified, and when these were resolved, a preliminary version of the online health promoting community was made available for tests. A checklist to be used to inform online health promoting communities based on information system evaluation research was formalized and formatively evaluated.

In Study I, we set out to determine the age for boys and girls at which PiBMI values begin to be associated with the corresponding measurements in late adolescence. We found a strong correlation ($r > 0.5$) between the intra-individual measurements from 5 years of age onwards. We also found that, in our study cohort, 23% of the girls and 8% of the boys defined as obese at age 5 years were of normal weight at the age of 15 years. Combining the facts that so few individuals had returned to normal weight from the age of 5 years and that intra-individual BMI values were strongly correlated from 5 years up to 15 years of age, we conclude that there are reasons for offering population-based interventions systematically from 5 years of age. This recommendation is supported by the reports from Kim et al.\textsuperscript{116} who found that prevention at 5–8 years of age was more successful compared with prevention when the children had reached 11–13 years. From the perspective of eventual health risks as adults, it would be worthwhile identifying at an early age those relatively few children with substantially increased risk of maintaining obesity.
in adulthood and offering them interventions; but interventions must be avoided when they are not necessary.

Point estimates of childhood obesity using IOTF cut-off limits for BMI have been found to have low sensitivity (6–15%) for predicting obesity and metabolic disorders in young adulthood\textsuperscript{31}. Study II was aimed at exploring weight trajectories for identification of adolescents at risk for developing obesity and metabolic disorders as adults, particularly children with a non-obese childhood BMI, and projecting the costs for a trajectory-adjusted strategy for obesity prevention. We used IOTF cut-off points to analyse the weight classification trajectories of 4312 children up to age 15 years. The present need for obesity prevention among adolescents is greater than the resources available. Our projections indicate that the trajectory-based strategy would benefit adolescents with more specified interventions without increasing the costs. Online behavioural interventions open up the possibility of providing obesity prevention programs to individuals at risk\textsuperscript{117}. Promising approaches include Internet-based coaching programmes for high-risk patients\textsuperscript{118}.

Based on the need found in Study II, Study III utilized design with participating adolescents and representatives from regional public health to develop and implement an online health promoting community. The study set out to examine what aspects of the structure and functions of an online health promoting community are critical to satisfy the needs of user communities and public health goals and service capabilities. The most important observation was that compromises in the online health promoting community design were needed to resolve conflicts involving the management of resources and responsibilities in the public health organization. In a comparable online health promoting community development initiative in Ontario, Canada (http://www.youthspark.ca), methods for systems development, sustainability, and evaluation of an online health promoting community have been comprehensively documented\textsuperscript{119}. The current results add knowledge about negotiation between public health interests and end-user needs in the online health promoting community design process.

Study IV set out to develop a checklist for pre-launch evaluation of online health promoting communities. Use of checklists has a long tradition in design methodology and has also been used in the development of health information websites\textsuperscript{120}. Checklists are heuristic sets of constructs and guidelines not meant
to be strictly adhered to. The objective of the current checklist is not to strive for online health promoting community conformity, but instead to make sure that central design questions are attended to and that there are clear arguments supporting each divergent design decision. The resulting checklist includes the following constructs: information quality, service quality and subjective norms. The most important result from its formative evaluation was the delicate balance between community autonomy and quality control in the formulation of the information and service quality constructs. In order to empower an online community, some control over content and moderation needs to be surrendered in a managed process.

**RELATION WITH PREVIOUS RESEARCH**

Obesity is a growing problem in developed nations. Currently one-third of US children are overweight or obese. Childhood overweight and obesity in European countries range from 8% to 30%. Although the situation in Sweden is not as alarming as in the United States, still one-fifth of young children are overweight and they remain so into adolescence as shown in Study I. In addition to promoting poor self-esteem, which may negatively impact social, psychological and educational development, paediatric and adolescent obesity is associated with serious medical problems affecting the cardiovascular and metabolic systems.

The proportion of obesity in the study cohort for this thesis project was relatively constant at 2–3% through the school years for girls; obesity in boys is steadily increasing over time. These findings are in concordance with previous Swedish cross-sectional studies. The prevalence of overweight and obesity among boys is often higher than in girls and higher at the younger age (4, 10 years) compared with adolescents (15–16 years). There are relatively few longitudinal cohort studies of BMI development in Swedish children. Data from a cohort (n = 3650) born between 1973 and 1975 in Gothenburg covering annual BMI values from 2 years of age to 15 years of age have been reported. A similar data set was collected from children (n = 2591) born in the southern suburbs of Stockholm in 1985–1987. A comparison of the BMI distribution from 2 years of age to 15 years of age between these cohorts showed that from the age of 7 years, the children born in 1985–1987 had higher BMI mean values than their counterparts born 12 years earlier. The authors concluded that
school-aged children may be more susceptible to obesogenic environmental exposure than younger children.

From the perspective of eventual health risks as adults, it would be worthwhile identifying those relatively few children with substantially increased risk of maintaining obesity in adulthood at an early age and offering interventions; but interventions must be avoided when they are not necessary. To identify children at risk, a simple decision protocol that can be used at well-child centres and in school health care is needed to identify individuals who are on trajectories that will lead to persisting obesity. Correspondingly, research is needed on cost-effective treatment programmes for young obese children. Present evidence suggests that long-term family-based behavioural interventions can achieve lasting weight reduction in this category of children.

Evidence on overweight and obesity based on weight history makes it possible to improve the performance of selection strategies when adolescents are provided with specific obesity preventive services. Using a projection from epidemiological data, Study II demonstrated that by basing the selection of adolescents for obesity prevention on weight trajectories, the load on highly specialized paediatric care can be reduced by one-third and total health service costs for obesity management among adolescents reduced by one-third. One out of five children can be selected for individualized interventions, such as motivational interviewing. However, before use in policies and prevention program planning, the findings warrant confirmation in prospective cost–benefit studies.

Web technology is becoming increasingly prevalent in health services. In a recent review of computer and web-based interventions to increase physical activity among adolescents, most interventions led to a significant increase in physical activity, but the effects were short-lived. Experiences from smoking cessation programs suggest that using only Internet initiatives based on social cognitive theory is not effective, but that a combination of cell phone technologies, peer-to-peer contact and web-based information on health and coping strategies can be a promising long-term treatment option. An online health promoting community is a community-based, long-term and inclusive health promotion approach. Recently, online communities have been used in health services for self-management and communities of practice. When such online health promoting communities are developed on a large scale, the
existing models for health promotion program implementation and evaluation must also be extended to fit the virtual setting. For instance, a possible problem with an online health promoting community initiative is that it may encourage young people to post and discuss health issues and problems in a manner that they later may come to regret. Even though it is easy to censor content after the fact, information online tends to persist. However, the development of privacy guidelines for social media and maturation of online behaviour may lessen the risks of sharing online.\textsuperscript{138}

There are several different uses for the checklist developed in Study IV. For instance, it can be used in conjunction with practical development guides for health promotion web resources\textsuperscript{119} to cross-validate results from requirements analyses and ensure that design specifications have a reasonable scope. In website design, a site can be redesigned or re-imagined after implementation, based on the availability of technologies such as cascading style sheets (CSS) and CMSs without having to alter the underlying technical architecture.\textsuperscript{139} However, first implementations become more or less fixed once the basic style of the website has become known and used. The logotype, layout, and colour scheme are intimately associated with a website image and radical re-imagination is more consequential the longer the time lapse after launch. The combination of the stickiness of website images and technical flexibility make it possible to allow stakeholders to improve the website using participatory methods.\textsuperscript{140}

\section*{Limitations}

One limitation of Studies I and II is that the children were followed only to 15 years of age. However, Wardle et al.\textsuperscript{124} found that obesity already existing in early adolescence (11 years of age) is a clear indication for persisting obesity, and Whitaker et al.\textsuperscript{141} have found that four out of five obese teenagers remain obese in adulthood. BMI was not originally designed for the purpose of assessing obesity in growing children. Alternative classifications of BMI measurements in children have been used, e.g. relative classifications where children over the 80th percentile for their respective age and gender are classified as overweight and those over the 95th percentile as obese.\textsuperscript{26–28} However, the IOTF criteria\textsuperscript{29} are based on an international cohort consisting of almost 200 000 individuals and relate to the risk for adult morbidity. The
Discussion

Results of Studies I and II were presented according to these criteria to make the broadest comparisons possible.

When interpreting Study II, it must be taken into consideration that the results are limited in several aspects. The economic projections were not calculated from costs recorded in the study county. As the aim was to compare hypothetical intervention strategies, standardized cost data from the literature were used. Similarly, a marginal costs model assuming the presence of a health service infrastructure was used for the analysis. This model also included some hypothetical elements. For instance, in Sweden pharmaceutical treatment for obesity can only be supplied to patients less than 18 years of age after permission from the Medical Products Agency. The Medical Products Agency can at short notice allow prescription of a specific drug to an individual patient by issuing a special license on a named patient basis. To establish the superiority of the trajectory strategy, it must be adapted, implemented and evaluated within a health service context, and the factual costs recorded and analysed. Furthermore, we did not record a metabolic profile at age 15 years and have not collected BMI data in adulthood; the detailed metabolic risk for each trajectory group is thus not known for this population. Weight-related data may be lacking in school health care records at present and documentation from earlier interventions may be unavailable. However, with the wider use of electronic health records, the possibility of using weight trajectories to inform screening of adolescents when they leave school health care will increase.

Study III has several limitations that need to be taken into account when interpreting the results. Community-based participatory research methods have inherent methodological challenges. Allowing practitioners and the target community to influence the qualitative analysis process may be interpreted as surrendering control of the study. However, in accordance with the suggested increased use of qualitative data from in-depth interviews and observations for evaluating the context, process, impact, and outcome of community-based interventions\textsuperscript{142-147}, we contend that the participatory method used in this study is adequate for capturing the context and process of the community development. In such interventions, experimental control may be incongruous when taking the different sociopolitical structures of communities into account\textsuperscript{143,145,148}. To ensure contextual soundness, in this study, the practitioners were included in their actual professional roles, and the adolescents were the users, rather than merely informants. In addition,
including young people from the end-user community from several municipalities and school programs in the research was an attempt to decrease the threats to soundness that are associated with a convenience sample and that the adolescents would be disingenuous.

There are also important limitations that must be taken into account when considering application of the results of Study IV. A checklist based on measures of information system success risks focusing online health promoting community design on tangible features that characterize successful online communities, rather than supporting health promotion success. Focusing on information system success rather than use alone may be one way to lessen this problem. Research on online communities has identified several constructs shown to be associated with both the use and perceived net benefit of online communities as an information system. The contextual adaptation of the constructs in this study resulted in items for content area, trust, format, staff competence, prompt service, empathy, social facilitation, inter-connectivity and communication. Nonetheless, these constructs cannot be regarded as a final set. For instance, no construct presently addresses online moral conduct, although the service quality construct covers the consequences of biases and lack of transparency. Vibrant communities exist today where the discourse is characterized as uncivil and destructive. It is currently held that online conduct is less civil than the offline counterpart, and the anonymity of the Internet has been proposed as an explanation. More importantly, no construct addresses health benefits per se. Health outcomes from an online health promoting community are difficult to determine in pre-launch evaluations. In contrast to online disease prevention efforts, online health promoting community outcomes are also challenging to define in the summative evaluation context. The checklist presented in this study is based on the tradition of information system success, with emphasis on providing benefit to communities as defined by the community. However, the benefits determined by the community may or may not correspond to the public health goals.

**Relevance for Public Health Practice**

The study cohort in this thesis project can be considered representative in that 14% were overweight and 4% were obese at 15 years of age. The proportion of those overweight was highest (17%) at the age of 10 years. The proportion of
Discussion

obesity was relatively constant at 2–3% through the school years for girls; obesity in boys is steadily increasing over time.

In the continuing efforts to prevent disease and promote health, every public health intervention must be evaluated in terms of benefit and side effects. Often the most effective approach to obesity prevention also brings forth stigmatization, which is seldom considered and evaluated in efficacy trials and randomized controlled studies\textsuperscript{151}. For instance, the very concept of overweight in childhood is by definition merely an epidemiological association with corresponding adult overweight classification\textsuperscript{29}. When working with children classified as overweight in this manner, it is thus an intervention for a risk factor (overweight in childhood) for a risk factor (overweight in adulthood) for obesity. In such cases, much care must be taken to avoid exposing children to harmful social and psychological interventions.

Childhood obesity determined by the IOTF reference BMI cut-off points has been found to have a high specificity (97–99%) for predicting obesity and metabolic disorders in young adulthood\textsuperscript{31}. That is, only a very small percentage of the individuals who are categorized in the low-risk groups in adulthood were obese as children. There are therefore reasons for categorizing children determined obese by the IOTF reference BMI cut-offs separately and providing them with extra resources for treatment and prevention. Moreover, our recent observations and those of others suggest that children belonging to the constant overweight (8.3% of the population at age 15 years in Study II) and turning overweight (4.1% of the population) trajectories should also be considered as candidates for individual obesity prevention before they develop obesity in adulthood.

Before public health providers invest resources in putting an online health promoting community design into routine practice, the design should be evaluated with regard to health effects and use patterns in the intended population. There is a need to evaluate both the use and effectiveness of the system using several methods, including web surveys, focus groups and controlled effectiveness studies. The large-scale implementation of an online health promoting community design in a practice setting, which is necessary for such an evaluation, is associated with methodological challenges. Participatory design proponents suggest that because the social factors important for the implementation are highlighted in a participatory design approach, the resulting systems are more sustainable compared with those
developed using traditional systems development methods\textsuperscript{152}. However, participatory methods have also been criticized for neglecting the later technical development stages\textsuperscript{153} and being unrealistic with regard to the resources demanded of practitioners\textsuperscript{154}. Techniques such as the Voice of the Customer table and House of Quality \textsuperscript{155} are well-established but time- and resource-consuming approaches to the problem of system accurateness.

Action research, as used in Study IV, is a contextual research approach\textsuperscript{104} and therefore generalizations, if done at all, should be done with caution. To ensure contextual soundness, health service practitioners participated in this study in their actual professional roles, and young people participated as online health promoting community users, rather than merely informants. The practitioners and young people thus both represented and reflected the infrastructure and processes of the Swedish health services and general society. The needs analysis, design, and validation of the online health promoting community were embedded in its regional context. Although the development of the initial version of the checklist was influenced by the experience and prejudices of the researchers, the formative evaluation data comprised factual decisions and adjustments made in the development process, thus limiting researcher influence. It may thus be possible that vital aspects of a pre-launch online health promoting community evaluation checklist eluded analysis in this study, but it is less likely that unfounded design arguments were introduced as data. Before using the checklist, a comparison of the infrastructure and processes of the study context from which the checklist was abstracted with the target context is needed in order to determine what aspects of the checklist are irrelevant\textsuperscript{156}.

**FUTURE RESEARCH**

Future studies to address evaluation of online health promoting communities are warranted. However, measuring community empowerment is associated with several methodological challenges. A central concept in design methodology is that the design itself will change the context for which it is designed\textsuperscript{71,73}. Furthermore, due to the sociotechnical development of the community, an adequate design at launch will probably not be appropriate for long, and the design will develop alongside the community structure and needs. Thus, traditional requirements for intervention evaluation such as
blinding and using static exposure are easily violated in the evaluation of online health promoting communities.

A proper evaluations framework of online health promoting communities should include the success of the community intervention both as an information system and as a health promoting initiative. The former answers the question if the community can be reached by the means of an online health promoting community and the latter if the intervention influences the community as intended. The first set of challenges is the measurement of community reach and influence on regional health services. Quantitative measures such as traffic, user experience questionnaires and information system assessment can be complemented by qualitative measures such as content analysis of online activity and focus groups of satisfied and dissatisfied user groups. However, as the design evolves based on continuous feedback from its community, the methods for book-keeping of feedback when adjusting the design over time needs to be addressed. For instance, a comment on a specific feature may be irrelevant, because the feature has already been modified due to previous feedback.

The second set of challenges is the measurement of health outcomes of health promoting initiatives. In contrast to disease prevention, it is more difficult to define and measure outcomes in health promotion. However, as described in this thesis, there have been several attempts to formalize and operationalize behaviour based on self-efficacy with similarities to the health promotion concept of empowerment. Self-efficacy is a general characteristic associated with empowerment and, without a specific intention, self-efficacy risks being too general to be of any use in health promotion. One direction put forth in the literature is to use health-specific self-efficacy associated with weight loss. However, more research on the application of psychological constructs in health promoting interventions is going to be needed. If the theory of planned behaviour is valid, self-efficacy can be used as a quantitative measure of empowerment. But as put forth by researchers in community-based participatory research, using simple quantitative measurements to operationalize social systems is ill-advised. Another direction for the future is to discern the goals and intentions of subjects through the use of qualitative approaches such as interviews and focus group interviews, more akin to approaches in community-based participatory research.
CONCLUSIONS

- In Study I we found a strong correlation \((r > 0.5)\) between the intra-individual BMI measurements from 5 years of age onwards and reasons for offering population-based interventions systematically from 5 years of age. It would be worthwhile identifying those relatively few children with substantially increased risk of maintaining obesity in adulthood at an early age and offer interventions; but interventions must be avoided when they are not necessary.

- The projections in Study II indicate that a trajectory-based strategy for categorizing adolescents at age 15 years with regard to obesity interventions would benefit adolescent populations with more specified interventions without increasing the costs.

- In Study III, we found than an online health promoting community can be designed simply at relatively low cost and can be negotiated to satisfy both the needs of the user community and public health goals and service capabilities. The main results were that compromises in the online health promoting community design were needed to resolve conflicts involving the management of organizational resources and responsibilities.

- In Study IV, a checklist for pre-launch evaluation of online health promoting communities was developed and included the following constructs: information quality, service quality and subjective norms. The most important result from a formative evaluation was the delicate balance between community autonomy and quality control in the formulation of the information and service quality constructs.
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