ABSTRACT

WHITLOCK, LAURA ANNE. Decision Support for Diabetes Self-Management: Quantitative and Qualitative Approaches. (Under the direction of Dr. Anne Collins McLaughlin).

Diabetes is a chronic, pervasive illness (CDC, 2014) that requires challenging self-management practices (Skinner et al., 2006). Both type 2 diabetes and prediabetes are common in older adults (Cowie et al., 2009), who may be at greater risk of struggling with self-management due to age-related cognitive change. Decision support systems may be developed to assist with self-management, but many questions remain about the specific type and level of support they should provide, particularly for older users and in the context of diabetes self-management. We conducted two studies to contribute to this knowledge area: a quantitative investigation of the effect of decision support levels and age on performance on a complex nutrition task (Study 1), and a qualitative coding study investigating the topics and types of support on an internet forum dedicated to the discussion of type 2 diabetes (Study 2). Study 1 revealed a significant effect of age on task performance such that younger adults outperformed older adults, but there were no significant differences in level of decision support or interactions between age and support in performance. Study 2 found that internet forum users exchanged both informational and emotional support. We describe the specific forms this support took as well as the topics most often discussed. Implications for the design of decision support systems are discussed, as well as the future studies that will be necessary to better inform the design of age-appropriate decision support for diabetes self-management.

Decision Support for Diabetes Self-Management: Quantitative and Qualitative Approaches

by
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BIOGRAPHY

Laura A. Whitlock was born in Morristown, New Jersey. She graduated cum laude from North Carolina State University in May 2008 with a Bachelor of Arts degree in Psychology and a minor in Middle East Studies. She then entered graduate school at North Carolina State University to pursue a degree in Human Factors and Ergonomics, working in the Learning, Aging, and Cognitive Ergonomics lab under the direction of Dr. Anne Collins McLaughlin. She received her Masters of Science and graduated with a Doctorate of Philosophy in the field of Psychology.

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Introduction

The Issue of Diabetes Self-Management

Type 2 diabetes is a serious chronic illness that is estimated to affect 29.1 million Americans, or 9.3% of the population of the United States (CDC, 2014). The physical health problems associated with unmanaged type 2 diabetes are severe and include increased risk of heart disease, kidney disease, stroke, blindness, limb dysfunction and amputation, infection, nerve damage, and chronic pain. In economic terms, the cost of medical treatments for diabetes, conditions associated with diabetes, and diabetes-related disability and early mortality were estimated to be $245 billion in the United States in 2012 (ADA, 2013). This represents a 41% increase in management costs since 2007 (ADA, 2013) and highlights the growing impact and cost of the disease, both to society and to the individuals who live with it.

How can the costs associated with diabetes most effectively be addressed? It is first important to understand the way in which type 2 diabetes is managed. Type 2 diabetes is a condition that predominantly requires the active involvement of the patient in day-to-day self-management at home (Skinner et al., 2006). The processes of self-management may include but are not limited to taking oral medications and/or injecting insulin, self-monitoring of blood glucose using a home glucometer device to take and record blood glucose measurements, knowing when to exercise or not exercise based on blood glucose measurements, using blood glucose measurements to adjust insulin doses as well as dietary variables like number of grams of carbohydrates, types of carbohydrates, and the times of day they are eaten.

These self-management practices are a challenge for many persons with type 2 diabetes. To be able to perform complex self-management behaviors, including making decisions about dietary choices, it is important that patients receive appropriate self-management education (Skinner et al., 2006). Self-management education has been found to improve glycemic control in persons with type 2 diabetes but the benefit declined over time after the delivery of the education (Norris et al., 2002). Many diabetes educators reported that their patients had difficulty in self-management skills like understanding a meal plan (Sprague et al., 1999).

Diabetes self-management is an area of special concern for older adults for two reasons. First, the prevalence of diabetes increases with age. Twenty-seven percent of adults aged 65 and older have diabetes and a further 40% have prediabetes (Cowie et al., 2009), a state of elevated blood glucose that is associated with a greater risk of diabetes and tends to progress to diabetes within ten years. This means that a full two-thirds of older adults have the potential to benefit from safe and effective self- management of dietary behavior. Second, age-related cognitive decline in fluid abilities (e.g. Salthouse, 2004) means that novel tasks and complex tasks tend to be more challenging for older compared to younger adults, putting older adults who must self-manage type 2 diabetes at a disadvantage. A potential solution may be an automated decision aid informed by the study of automated systems, as well as by the ways real people with diabetes seek information and advice.

Automation and Automated Systems

One approach to improving diabetes self-management may be the implementation of automated decision support, which is lacking in existing mobile applications designed to assist with diabetes self-management (Whitlock & McLaughlin, 2012; Whitlock, McLaughlin, Harris, & Bradshaw, 2015). Automation can be described as the process by which a machine carries out a function previously carried out by a human (Parasuraman & Riley, 1997).

Non-automated decision aids have been well-studied in the healthcare domains in terms of screening or treatment decisions and have been found to improve knowledge and encourage patients to be more active in decision making without increasing their anxiety (O'Connor et al., 1999). They tend to be non-interactive and often take the form of paper handouts detailing outcomes and other factors relevant to a medical decision. Less is known about the effects of automated decision support for patients, particularly those intended to support them during a task instead of during a single medical decision. However, the general body of knowledge about automation and its use may inform the design of an automated decision support system for these goals.

Levels and functions of automation. The extent to which automation augments or replaces human task performance can be described across a continuum of levels. The lowest level of automation describes a state of fully manual human performance, while the highest level involves a system functioning with full autonomy and receiving no input or oversight from a human operator. Between these two extremes of automation are levels with some degree of sharing of function between the automated system and the human operator. These "in betweens" of automation can be classified in many ways, but a general model might consist of five levels: (1) none; (2) low; (3) medium; (4) high; and (5) full (Parasuraman, 2010).

Automation can also be described across different stages or functions. Parasuraman, Sheridan and Wickens (2000) proposed a model of automation that described differing levels of automation across four distinct functions: information acquisition, information analysis, decision selection, and action implementation. These functions correspond to a four-stage model of human information processing that consists of sensory processing, perception/working memory, decision making, and response selection. Each function of automation augments or replaces human performance at the corresponding stage of human information processing, e.g. the information acquisition function occurring at the stage of sensory processing. Information acquisition and analysis can be described as input functions, or those that precede the stages of decision making and action, or as output functions that apply to the automation of decision and action selection (Parasuraman, Sheridan, & Wickens, 2000).

Thus, we can describe the implementation of automation as occurring at a distinct function and operating at a certain level. For example, the output functions of decision and action selection have been classically described with a 10-level classification (Sheridan, 1992; Wickens, Mavor, Parasuraman, & McGee, 1998) where each level represented a successively more autonomous system with less human performance. At a lower level (e.g., 3) the system offers a select set of decision or action alternatives to the human operator and the operator has full control to decide which, if any, to implement. At a moderate level (e.g.,

5) the system suggests one decision or action and executes it if the operator approves. However, at a higher level of 8 the system selects a decision or action, executes it, and only informs the operator of its action if asked.

Information acquisition. Automation of the function of information acquisition involves the tasks of sensing and registration of input data, supporting human sensory processes involved in early information processing. A moderate level of automation of this function involves altering the organization or appearance of incoming information according to predetermined criteria, such as reordering a list to present higher priority items first, or highlighting priority items to draw the operator's attention to them. With a moderate degree of automation of information acquisition, all original incoming information is preserved and reaches the operator, although the order or appearance of the information may be altered. At a higher level of automation of information acquisition, the automated system may select which items of information to show the operator and which to hide, a process described as filtering. Once filtering is implemented the full content of the raw data are no longer available to the operator. For example, if the data in a nutrition label were filtered, only the information a user needed for the immediate task would be visible.

Information analysis. Automation of the function of information analysis supports the operator's higher cognitive functions, such as working memory, by processing incoming information before the operator uses it to make a decision. The information analysis automation may convert raw input data into a form whose relationship to the criterion is easier to understand, or apply extrapolation algorithms to incoming data to predict future trends or outcomes. For example, information analysis included on a nutrition label might show the user the percent of calories a food item contributes to their target calorie total for a given meal, putting the raw data of calories into a context that is meaningful to the task at hand.

Downsides of automation. However, automation is not a panacea for performance. There can be consequences associated with its implementation that affect how the operator performs both with and without the support of the automated system (Parasuraman & Riley, 1997). As Parasuraman, Sheridan, and Wickens (2000) pointed out, working in conjunction with automation fundamentally changes the way the human operator functions and may lead to unintended consequences. Automation misuse is an outcome in which operators over-rely on the automation, and is typically conceptualized as using or monitoring automation inappropriately (Parasuraman & Riley, 1997).

Even when the operator uses the automation appropriately, problems may occur due to its use. Reliance on automation may lead the operator to experience degradation in the skills necessary to perform the task in the absence of automation (e.g. Wiener & Curry, 1980), including cognitive skill degradation. This can occur when higher-order cognitive skills, like decision making or analysis, are consistently performed by the automation and not the operator. Through disuse, the operator's capacity to perform those skill-based tasks without the aid of the automation declines. The effects of these degraded skills may not be apparent until automation fails or the operator is required to function in its absence. An automated decision aid designed to keep performance high in the short term may therefore have the unintended consequence of damaging the acquisition and maintenance of cognitive skills over time, leading to the undesirable situation of users who are reliant on decision support and cannot function well without it. The goal of much automation research is to understand how to help users properly calibrate their trust in the system, so that when an automation failure occurs they are ready to perform the task manually and have a good mental model for how to do so (McGuirl & Sarter, 2006).

Automation and older adults. A lifespan perspective of aging acknowledges the gains, losses, and fundamental changes that may occur with age (Baltes, 1987). Cognitive aging (see Park & Schwarz, 1999 for an overview) is a well-studied phenomena and includes age-related decline in cognitive abilities like speed, reasoning, and memory (Salthouse, 2004) although some skills show improvement across much of the lifespan, such as performance on vocabulary tests (Salthouse, 2003). Given the cognitive changes that may occur with age, examining age-related differences in the use of automated systems is a necessary step to improve their design and use by persons of all ages.

Age differences in automation use is an emerging research area and has often focused on issues relating to trust, reliance, and response to automation failures (Ezer, Fisk, & Rogers, 2008; Ho, Wheatley, & Scialfa, 2005; Pak, Fink, Price, Bass, & Sturre, 2012; Sanchez, Fisk, & Rogers, 2004). Ho, Wheatley, and Scialfa (2005) examined the use of an automated decision aid during a medication management task and found that older adults relied more on the aid than younger adults and were less likely to notice automation failures. Another study examined age-related differences in reliance on automation and found that older adults were less responsive to changing costs of error, and that this lack of responsivity might have resulted from a decreased ability to monitor and adapt to changing costs as compared to younger adults (Ezer et al., 2008).

However, another study found that older adults were actually more able to detect different levels of automation reliability than were younger adults. Sanchez, Fisk, and Rogers (2004) used a driving-like task to examine age differences in perceived reliability and trust of an automated aid at varying levels of reliability. Compared to younger adults, older adults were more sensitive to changes for the two mid-levels of reliability and also reported significantly different levels of perceived reliability and trust in the automation between these two levels, while younger adults did not. Interestingly, for both the highest and lowest reliability settings older adults tended to underestimate the reliability of the automated system. Other work examining the effect of anthropomorphic characteristics on automated decision aid use found that younger but not older adults showed inappropriately increased trust when using an aid with anthropomorphic characteristics (Pak et al., 2012).

Taken together these studies show that not only can age-related differences influence the use of automated decision aids, but that the effect is not always predictably in the favor of one age group over the other. Further research is needed to better understand the relationship between age and use of automation. Furthermore, it is important to note these studies focused on the output functions of automated systems, which were those that applied to the selection or implementation of an action. Input functions that relate to the processes of information gathering and analysis may be automated as well (Parasuraman, 2000), and fewer studies address these types of automated systems. Literature on environmental support may contribute to predictions about the use of automated systems that assist the user with information gathering and analysis. Morrow and Rogers (2008) described an integrative framework of environmental support where environmental support can guide the allocation of cognitive resources by cueing users' attention to the most relevant information for the task at hand. This mirrored the highlighting function of information acquisition in an automated system. Research on age-related differences in the use of environmental support (Morrow et al., 2003) suggested that older adults were able to take advantage of domain-relevant environmental support to maintain performance on complex tasks despite age-related declines in cognitive ability, as long as they had background expertise in the task. However, the application of these findings to other domains may be limited, given that the study examined environmental support in the domain of air traffic control communication, a high performance task whose practitioners have many years of intense experience and training. Questions remain about the extent to which these findings would translate to contexts with non-expert users who require training.

Literature on age-related differences in training efficacy has found that the type of training that enhances short-term performance may be incompatible with the type of training that best promotes learning. One study (Hickman, Rogers, & Fisk, 2007) compared guided action training, which assists users by telling them the steps needed to perform a task, to guided attention training, which assists users by helping them properly allocate their attention during the task. Guided action training was more supportive of fast and accurate performance, but guided attention training was more supportive of learning (Hickman, Rogers, & Fisk, 2007). Applying these findings to automated systems, it is possible that a system that provides the user with the wrong kind of support during a task could improve performance in the short term but ultimately hinder learning.

Although the literatures on automation use and design for older adults are large, there are no easy answers for how to best design a decision support system for a complex, ongoing task like diabetes self-management, particularly when the needs of older users are of central concern. Too much of the wrong kind of support could impede the user's development of an underlying mental model of the tasks involved in self-management. This is a concern both in terms of allowing the user to detect and respond to failures of automation, and also in terms of the acquisition and maintenance of the knowledge and cognitive skills required by the task. To inform the design of such a system more evidence is needed about the role of different forms of information acquisition and analysis support, their effects on performance and learning, and the possibility of age-related differences in these outcomes.

Internet Forums and the Design of Diabetes Decision Support Systems

Another possible source of data to inform the design of automated decision support systems for diabetes self-management exists in the form of diabetes internet forums. An examination of posts made by users on diabetes internet forums could address more applied questions to guide the design of such a system. For example, determining which aspects of self-management such a system might target, how it might convey information to the user, and other features it might have to support self-management. With regards to the aspects of self-management most in need of support, our early investigations into the content of diabetes internet forums suggested that much of the difficulties experienced during diabetes self-management center around dietary behavior. However, further analysis was needed to determine which topics were discussed most frequently on the forum, and how users discussed them. The frequency and delivery of topics might suggest the areas in which users need more support and avenues that could be taken to provide that support via an automated system.

The National Standards for Diabetes Self-Management Education and Support (Haas et al., 2014) put forth core curriculum topics that should be included in educational and support programs for persons with diabetes. These core curriculum topics include the knowledge and skills necessary to best support effective diabetes self-management. These topics may be classified according to those that align more as necessitating informational support, emotional support, or both (Table 1). Topics that require the individual to know something could be classified as necessitating informational support, while those that require the user to appropriately and consistently engage in a behavior could be classified as requiring both.

Table 1. Core Curriculum for Diabetes Self-Management Education

Informational Support
Describing the disease process
Describing treatment options
Informational and Emotional Support
Incorporating nutritional management into lifestyle
Incorporating physical activity into lifestyle
Monitoring and interpreting blood glucose
Using medication(s) safely and effectively
Preventing, detecting, and treating acute and chronic complications
Emotional Support
Developing personal strategies to address psychosocial issues
Developing personal strategies to promote health and behavior change

Note. Curriculum topics drawn from Haas et al., 2012, and categorized according to a conceptualization of their socioemotional support requirements.

In preliminary work done for the current study it was found that lay experts on these forums assist others by providing informational and emotional support to address a variety of aspects of diabetes self-management. Existing studies of diabetes internet forums, although helpful, have so far largely limited their investigations to broad content categories like "requesting information," "providing information," "emotional content," "community building," and "irrelevant" (e.g. Greene, Choundhry, Kilabuk, & Shrank, 2010; Zhang, He, & Sang, 2013). By further breaking down the types of information and emotional content, conceptualized as informational and emotional support, data obtained via a more fine-grained coding system could provide further evidence to guide the design of an automated system.

A comprehensive coding scheme could also identify posts relevant to investigate future research questions. For example, while prior research has examined the cognitive processes underlying diabetes self-management via investigations into the mental models and problem solving processes of persons with diabetes (Lippa & Klein, 2006), small sample sizes have been a limitation. A large-scale coding scheme with a diversity of codes could identify posts likely to address specific research questions, e.g. relating to collaborative diabetes problem solving or technology use. This would provide an alternate approach for future investigations into these topics, with different advantages than the methods used by prior studies.

Thus, a quantitative examination of a diabetes internet forum can provide two important streams of information: 1) the kinds of topics most discussed on the forum and their relation to existing curriculum recommendations for diabetes self-management education and support, and 2) the nature of the informational and emotional support sought by persons trying to self-manage diabetes. Such information could aid in the more applied aspects of the design of a decision aid, allowing its design to be based on the successful elements of an online diabetes self-management community.

General Overview

Two studies were conducted to contribute to both theoretical (Study 1) and applied (Study 2) questions about the design of automated decision support systems to promote the self-management of diabetes in older adults. Each study contributes to an improved understanding of the needs of users and their use of decision aids. The hypotheses for Study 1 were twofold:

Hypothesis 1: Higher levels of decision support are expected to lead to higher task performance when the task is performed with the decision support. This effect is expected to be stronger for older adults than younger adults.

Hypothesis 2: Lower levels of decision support during task performance are expected to lead to greater learning of the underlying skills required by the task. This is expected to be evident by greater maintenance of task performance after the decision support is removed. This effect expected to be stronger for older adults than younger adults.

Study 1 - The Effect of Age and Level of Decision Support

Method

Participants

Participants aged 65 or older were recruited through a database of older adults who had participated in past psychology research at the university and through newsletters and announcements at a local senior living community. They completed the study in person using a computer. Younger adult participants aged 64 or younger were recruited through Amazon's Mechanical Turk service website (see Buhrmester, Kwang, & Gosling, 2011, for an overview of the use of the Mechanical Turk service for psychological research). They completed the study over the internet using a computer. Participation in the study was limited to those who lived in the United States and who spoke English as a primary language. Older adults received $10.00 each in compensation for their time, and younger adults received $8.00 each. Differences in compensation reflected the difference in time to complete the study.

All 33 older adults who began the study completed it. Three younger adults dropped out during the presentation of the task instructions, and a total of 33 older and 37 younger adults completed the study. However, timestamps embedded in the experimental task suggested that two younger adult participants did not complete the task as instructed because they took only a few seconds to submit answers for each item. Therefore, the results from two younger adult participants were excluded from analysis and the analyzable sample consisted of 33 older adults and 35 younger adults.

Table 2. Demographic Characteristics by Age Group

	N = 35 Younger	*N* = 33 Older	
Gender			
Female	*n* = 18	*n* = 21	
Male	*n* = 17	*n* = 12	
	M (*SD*)	*M* (*SD*)	*p*
Age*	35.60 (*9.23*)	81.59 (*7.97*)	$p < .01$
Diabetes			
Knowledge	59% (*10%*)	62% (*11%*)	$p = .36$
Education*	5.03 (*2.28*)	7.61 (*1.48*)	$p < .01$

* indicates significant difference between groups at $p < .01$

Notes. Diabetes knowledge was represented as a percent score. Education was scaled with 1 = some high school or less, 2 = completed high school, 3 = completed trade/vocational school, 4 = some 2-year college, 5 = some 4-year college, 6 = graduated with 2-year degree, 7 = graduated with 4-year degree, 8 – some advanced or graduate degree, 9 = completed advanced or graduate degree.

Materials

All materials were created using the Qualtrics survey platform.

Demographic questionnaire. Background information on the participants was collected by a demographic survey that included questions about participants' age, gender, level of education, and self-rating of health. Education was rated on a 9-point scale from "some high school or less" to "completed advanced or graduate degree."

Nutrition label knowledge and proficiency. Self-assessment of nutrition knowledge and proficiency was measured through three questions answered on a 5-point Likert scale from “Strongly agree” to “Strongly disagree.” 1. “I understand how to read the nutrition labels of foods.” 2. “If I had to, I could use the information on the nutrition labels of foods to put together meals that meet nutritional requirements.” 3. “I am confident in my ability to use nutrition labels to count grams of carbohydrates and grams of fat to make healthy meals.” Summed scores were calculated to represent self-assessment of nutrition label knowledge and proficiency; higher scores indicated greater confidence in one’s knowledge and proficiency.

Diabetes Knowledge Questionnaire. The questionnaire was based on the Diabetes Knowledge Questionnaire (Garcia et al., 2001), which originally consisted of yes or no questions about diabetes facts. Participants completed an adapted version of the questionnaire that included five items (see Appendix for the questionnaire). Examples included “Eating too much sugar and other sweet foods is a cause of type 2 diabetes,” and “For a person with type 2 diabetes, an insulin reaction is caused by too much food.” The original questionnaire consists of “yes” or “no” answers; our adapted version asked participants to indicate agreement in a 5-point scale from “Strongly agree” to “Strongly disagree” to capture the degree of certainty participants had for their answers. Scores consisted of a percent score, such that strong agreement with correct statements and strong disagreement with incorrect statements would result in a score of 100%.

Experimental task. The task consisted of four phases: practice, pre-test, treatment, and post-test. During all phases except the practice, participants were asked to pick the best combination of foods to simultaneously meet a calorie goal and a net carbohydrate goal. Each problem contained six nutrition labels for six foods, e.g. tofu, mashed potatoes, chicken and rice soup, chicken drumstick, fried chicken, baked sweet potato. Participants could select one to six items. The optimal answer for each problem consisted of one to three food items that combined to best meet both goals. No optimal answer perfectly met the calorie and net carbohydrate goals, but they were designed so that no other combination of food items was a better fit for both goals. For each phase, time spent during the phase and the number of mouse clicks was recorded for all participants.

Practice. All participants completed an initial practice during which they received instructions on how to calculate net carbohydrates by subtracting the dietary fiber content from the total carbohydrate content. After the instructions they were given two sample problems. For the first sample problem they were asked to calculate the number of grams of net carbohydrates in a food item based on its nutrition label. Net carbohydrates are calculated by subtracting grams of fiber from the total carbohydrate count. They were told the correct answer on the next screen, as well as an explanation of the reasoning behind the correct answer.

For the second sample problem, they were shown the nutrition labels for three different foods, and asked to pick the foods that could make a meal that best met both a calorie goal and a goal of net carbohydrates. They were instructed that they could choose one to three food items, and that they just needed to try to get close to the calorie goal and the net carbohydrate goal. The instructions for calculating net carbohydrates were given to them again next to the question. After selecting their chosen food item or items, they were given the correct answer and the explanation on the next page. The explanation was paired with another picture of the nutrition labels for the three foods so they could follow along with the explanation (Figure 1). After the two sample items, participants were then told they would be completing the rest of the problems on their own. They were once again given the instructions for calculating net grams of carbohydrates, and asked to work quickly and accurately.

The best answer is **chicken dumpling soup** and **spinach**.

Chicken dumpling soup has 15g of net carbohydrates (18g of total carbohydrates, minus 3g of fiber, equals 15g of net carbohydrates). **Spinach** has 3g of net carbohydrates (7g of total carbohydrates, minus 4g of fiber, equals 3g of net carbohydrates). Together, they have 18g of net carbohydrates, which is very close to the goal of 20g of net carbohydrates. Together, they also have 232 calories, which is very close to the goal of 230 calories.

Black beans is a good answer in terms of calories, but it is not the best answer because by themselves they have 26g of net carbohydrates (41g of total carbohydrates, minus 15g of fiber), which is too many.

Chicken dumpling soup

Amount Per Serving	
Calories 191	Calories from Fat 81
	% Daily Value*
Total Fat 9g	14%
Saturated Fat 2g	10%
Trans Fat 0g	
Cholesterol 24mg	8%
Sodium 889mg	37%
Total Carbohydrate 18g	6%
Dietary Fiber 3g	12%
Sugars 2g	
Protein 8g	
Vitamin A 50% • Vitamin C	0%
Calcium 2% • Iron	0%

Black beans

Amount Per Serving	
Calories 227	Calories from Fat 8
	% Daily Value*
Total Fat 1g	1%
Saturated Fat 0g	1%
Trans Fat	
Cholesterol 0mg	0%
Sodium 408mg	17%
Total Carbohydrate 41g	14%
Dietary Fiber 15g	60%
Sugars	
Protein 15g	
Vitamin A 0% • Vitamin C	0%
Calcium 5% • Iron	20%

Spinach

Amount Per Serving	
Calories 41	Calories from Fat 4
	% Daily Value*
Total Fat 0g	1%
Saturated Fat 0g	0%
Trans Fat	
Cholesterol 0mg	0%
Sodium 126mg	5%
Total Carbohydrate 7g	2%
Dietary Fiber 4g	17%
Sugars 1g	
Protein 5g	
Vitamin A 377% • Vitamin C	29%
Calcium 24% • Iron	36%

Figure 1. Practice problem example. Participants are shown the correct answer for a practice problem where the correct answer was a combination of two food items, chicken dumpling soup and spinach.

Pre-test. The pre-test consisted of five problems in which participants were asked to combine foods to best meet a calorie goal and a net carbohydrate goal. Participants in each support condition saw the same version of each problem with no additional support provided (Figure 2), and saw the answer choices with no additional support provided (Figure 3). Participants were given a maximum of 900 seconds to answer all five problems before the task automatically advanced to the treatment phase.

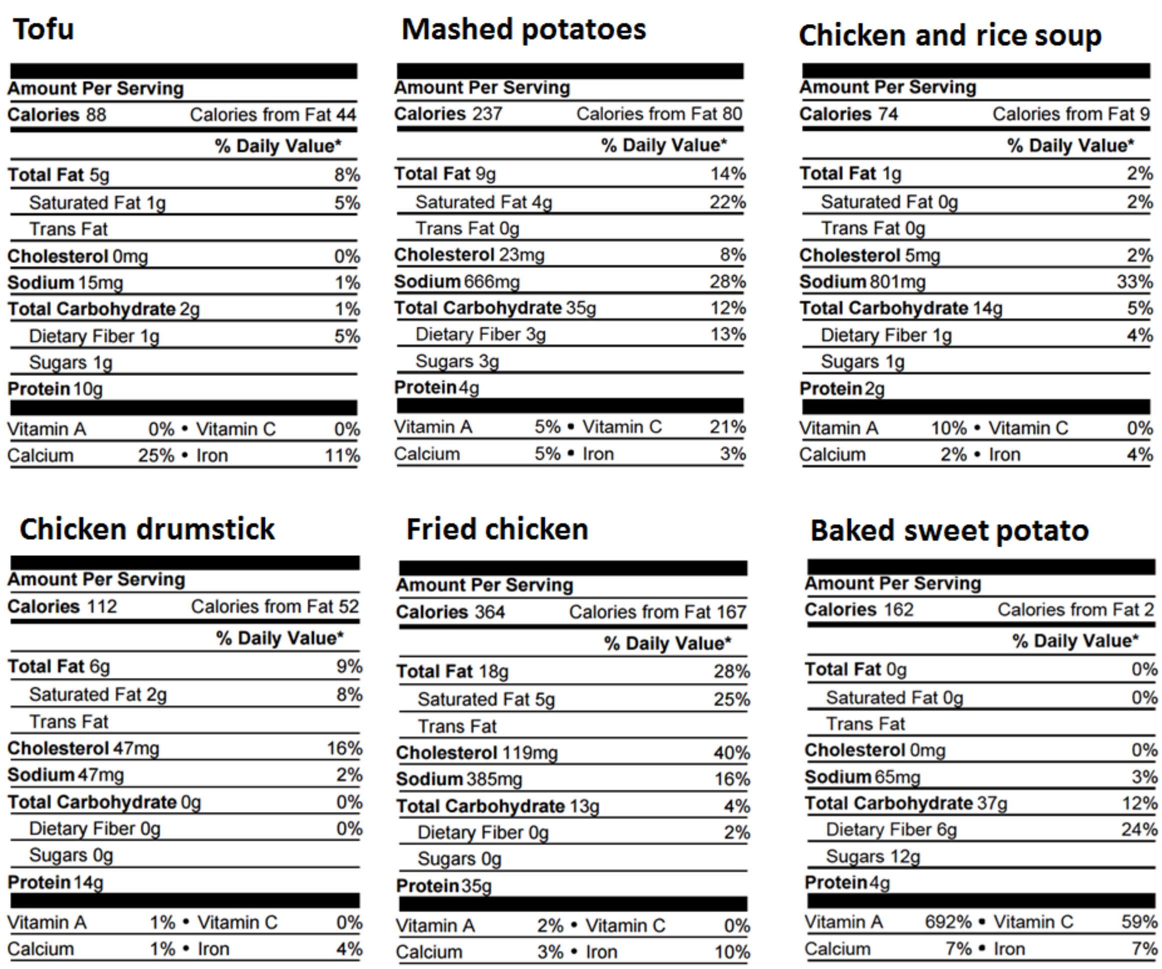
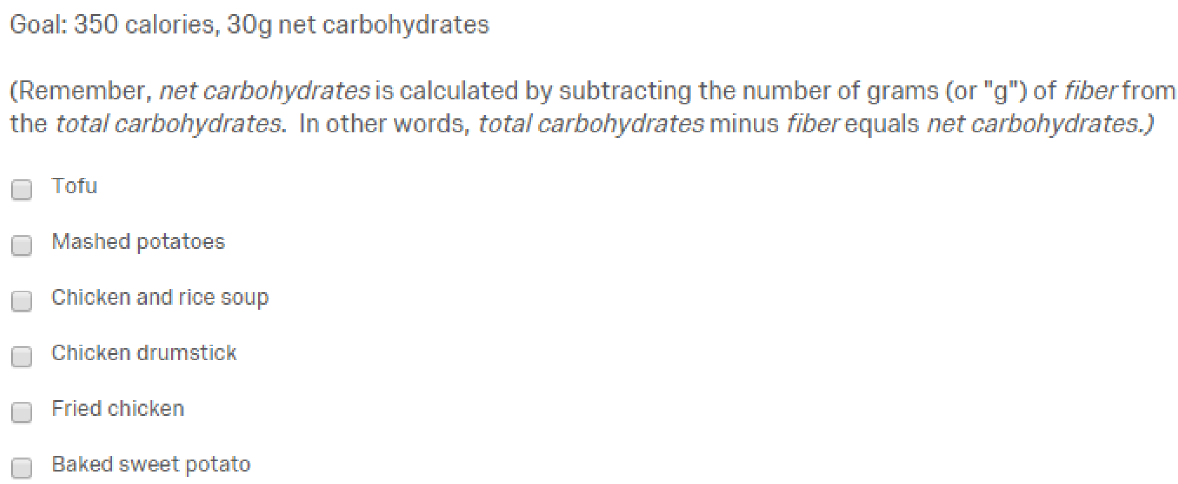


Figure 2. Pre- and post-test nutrition labels. Nutrition labels as seen for the problems given during the pre- and post-test phases for all support conditions.


Goal: 350 calories, 30g net carbohydrates

(Remember, *net carbohydrates* is calculated by subtracting the number of grams (or "g") of *fiber* from the *total carbohydrates*. In other words, *total carbohydrates* minus *fiber* equals *net carbohydrates.)*

- [ ] Tofu
- [ ] Mashed potatoes
- [ ] Chicken and rice soup
- [ ] Chicken drumstick
- [ ] Fried chicken
- [ ] Baked sweet potato

Figure 3. Pre-test, post-test, and low support condition goal and answer choices. Goal and answer choices as seen during pre- and post-test phases for all support conditions, and as seen during the treatment phase for the low support condition.

Treatment. The treatment consisted of ten problems in which participants were once again asked to combine foods to best meet a calorie goal and a net carbohydrate goal. However, this time participants saw a different version of the nutrition labels and possible food choices based on their experimental condition: low support, medium support, or high support (Table 3). Participants were given a maximum of 1800 seconds to answer all ten problems before the task automatically advanced to the post-test phase.

Table 3. Decision Support Conditions and Amount and Format of Support

	Information Acquisition (*Lower or Higher*)	Information Analysis (*Absent or Present*)
Low Support		
Amount	*Lower*	*Absent*
Format	Highlighting	
Medium Support		
Amount	*Lower*	*Present*
Format	Highlighting	Calculations
High Support		
Amount	*Higher*	*Present*
Format	Filtering	Calculations

Note. Each level of support (low, medium, high) is broken down according to the amount and format of the individual support components. For example, the low support condition consisted of highlighting as a lower amount of information acquisition support, and contained no information analysis support.

In the **low** support condition, participants saw the nutrition labels with total carbohydrates highlighted and outlined in red and dietary fiber highlighted and outlined in green (Figure 4). If an item contained 0g of fiber, there was no green highlighting. The highlighting functioned as information acquisition support (Parasuraman, Sheridan, & Wickens, 2000). In the **medium** support condition, participants saw the same highlighting as in the low support condition, and were also given additional information about each food item. This additional information consisted of the grams of net carbohydrates, calculated for them, and the percent of the calorie goal each item represented (Figure 5). For example, they might be told that the spinach had 3g of net carbohydrates, and that it made up 10% of the calorie total. This functioned as information analysis support. In the **high** support condition, participants were given the same information and calculations as in medium support. However, the nutrition labels they saw for each food only showed the information necessary for the task (Figure 6).

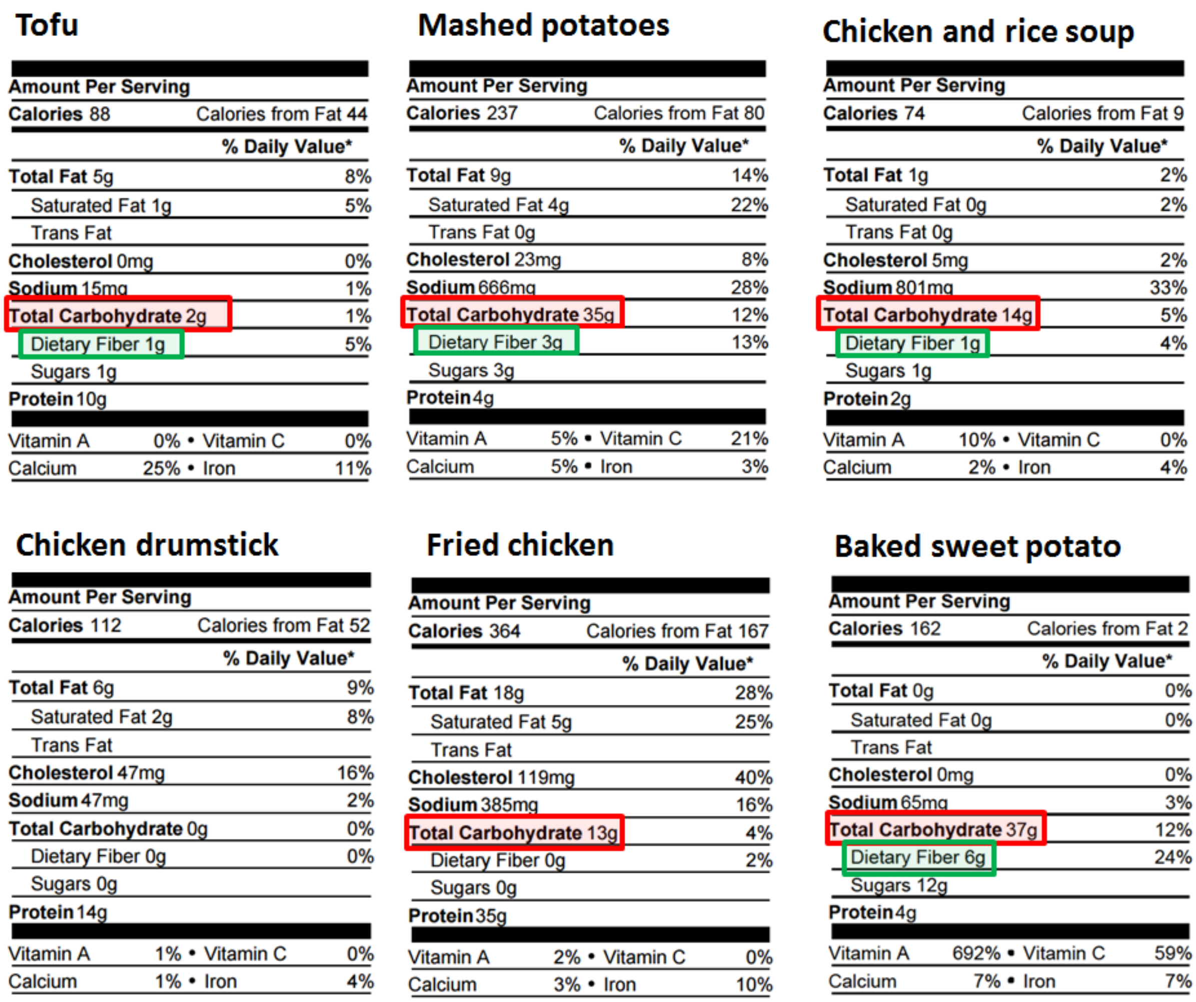


Figure 4. Treatment nutrition labels for the low and medium support conditions. The nutrition labels as seen by the low and medium support conditions during the treatment phase. The highlighting seen here functioned as a lower level of information acquisition support.

Goal: 400 calories, 20g net carbohydrates

(Remember, *net carbohydrates* is calculated by subtracting the number of grams (or "g") of *fiber* from the *total carbohydrates*. In other words, *total carbohydrates* minus *fiber* equals *net carbohydrates.)*

- ☐ Chicken noodle soup (net carbs: 12g, calories: 28% of total)
- ☐ Italian sausage, pork (net carbs: 4g, calories: 72% of total)
- ☐ Creamy tomato soup (net carbs: 22g, calories: 39% of total)
- ☐ Spinach (net carbs: 3g, calories: 10% of total)
- ☐ Milk, skim (net carbs: 12g, calories: 22% of total)
- ☐ Shrimp, fried (net carbs: 10g, calories: 52% of total)

Figure 5. Treatment goal and answer choices as seen during the treatment phase for the medium and high support conditions. Here, the calculations of net carbohydrates ("net carbs") and the percent of the calorie goal represented by each item functioned as information analysis support.

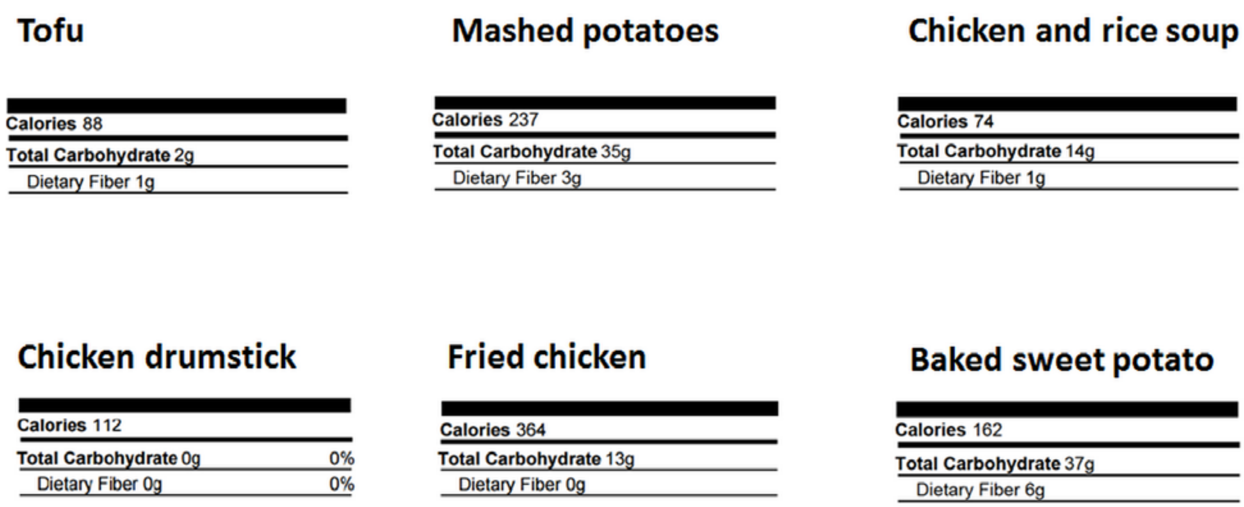


Figure 6. Treatment nutrition labels for the high support condition. The shortened labels shown here included only the information necessary for the task, and functioned as a higher level of information acquisition support.

Post-test. The post-test consisted of five problems. Like the pre-test, no support was provided. Participants were given a maximum of 900 seconds to answer all five problems before the task automatically advanced to the follow-up questionnaire.

Exit questionnaire. The exit questionnaire assessed participants' subjective experience during the task. Participants were asked to respond using 5-point scales to questions about their subjective experience with the task, including questions about the level of difficulty and fatigue they experienced during it. All participants were also given a free-response question asking if there was anything else they would like to say about their experience with the task or with the study in general.

Participants received separate questions depending on their experimental condition. Participants who saw highlighting (Low and Medium support groups) were asked how helpful the highlighting was, how trustworthy it was, and how much they would prefer to see highlighting instead of regular nutrition labels. Participants who were given calculated net carbohydrates and calorie percent values (Medium and High support groups) were asked how helpful it was, how trustworthy it was, and how much they would prefer being shown that information instead of receiving only regular nutrition labels. Participants who saw the smaller, simplified nutrition labels (High support) were asked how helpful it was to have simplified labels, how much easier it was to read simplified labels compared to the normal, large labels, and how much they would prefer simplified labels over normal, large labels.

Design

The between-participant independent variables were age group (older or younger) and level of decision support (low, medium, or high). The within-participant independent variable was test phase: pre-test, treatment, and post-test. The main dependent variables were phase accuracy, consisting of summed scores of correct answers for each phase (pre-test, treatment, post-test), and a total score consisting of the summed score for the three phases combined. Other dependent variables included subjective ratings of difficulty, fatigue, subjective self-assessment of performance, and preferences for and trust in the different components of decision support (highlighting, filtering, and calculations). Participants only provided preference and trust ratings for decision support components that they saw. For example, participants in the High support condition rated the filtering component and the calculating component, but not the highlighting component because it was not part of their decision support condition.

Procedure

Participants were randomized to one of the three treatment conditions: low, medium, or high support. After providing informed consent, participants began the study. First, they completed the demographics questionnaire, the modified Patient's Diabetes Knowledge questionnaire, and the nutrition label knowledge and proficiency questionnaire. They then completed the experimental task, consisting of the practice, pre-test, treatment, and post-test. They then completed the exit questionnaire. Last, they were thanked for their participation, compensated, and given the opportunity to ask any questions about the study. Older adult participants were able to ask and receive answers to questions about the study in person. Younger adults were shown the contact information for researcher if they had any questions.

Results

Group Comparisons at Pre-Test

A one-way multivariate analysis of variance (MANOVA) was performed to examine differences between the decision support groups on participant characteristics and pre-test performance. There was no significant effect of decision support group on scores during pre-test, $F(2,65) = .06$, $p = .95$, indicating that performance did not differ between the groups at the baseline measurement of task performance, prior to exposure to the decision support conditions. There were no significant differences between the groups, except on scores of diabetes knowledge. Because homogeneity of variance was violated for comparisons of diabetes knowledge (Levene's, $p = .04$) a Welch test was performed and found a significant difference between groups, $F(2, 40.93) = 5.72$, $p < .01$. A Games-Howell post-hoc analysis of comparisons of diabetes knowledge found that the high support group had significantly less knowledge than the Medium support group ($p < .01$) but did not significantly differ from the low support group ($p = .08$).

The results of the MANOVA suggest that it is unlikely there were significant pre-existing differences between decision support groups prior to the treatment. Although diabetes knowledge did differ significantly in the high support group, because there were no significant differences between decision support groups for pre-test scores it is unlikely that this group difference impacted performance.

Table 4. *Decision Support Condition Between-Group Differences at Pre-Test*

	Low Support	Medium Support	High Support	
Sample size	22	22	24	
	M (SD)	*M (SD)*	*M (SD)*	*p*
Age	59.77 (24.56)	58.10 (24.58)	55.08 (25.74)	0.82
Education[1]	6.18 (2.38)	6.36 (2.50)	6.29 (2.18)	0.98
Health[2]	5.64 (1.09)	5.77 (1.23)	5.75 (1.03)	0.91
Diabetes Knowledge[3]	62.27% (12.51)	63.64% (9.66)	55.42% (7.79)*	0.01
Nutrition Label Knowledge[4]	3.88 (.76)	4.20 (.66)	4.15 (.60)	0.24
Pre-test Task Score	1.27 (.99)	1.18 (1.30)	1.29 (1.20)	0.95

Note.
* Indicates significant difference from both other groups at $p < .05$
[1] Reported on a 7pt scale from '1 - Some high school or less' to '9 - Completed advanced or graduate degree'
[2] Self-rated on a 7pt scale from '1 - Very bad" to '7 - Very good'
[3] Scored as percent correct
[4] Higher scores indicate greater confidence in one's nutrition label knowledge and proficiency

A one-way ANOVA was performed to examine age group differences in pre-test scores. There was a significant difference between pre-test scores, $F(1, 66) = 8.7$, $p < .01$, $\eta^2 = .12$, such that younger adults scored significantly higher ($M = 1.63$, $SD = 1.22$) than older adults ($M = .85$, $SD = .94$).

Effect of Decision Support

A 2 x 3 x 3 mixed design ANOVA was performed to examine the effect of the between-participants variables of age group (younger, older) and decision support group (low, medium, high) on the scores for each participant during the three phases: pre-test, treatment, and post-test. To allow comparisons between phases, treatment scores were divided by two to account for the fact that participants completed twice as many questions during the treatment phase as during the pre-test phase. Mauchly's Test of Sphericity was significant, $\chi^2(2) = 7.64$, $p = .02$ and $\varepsilon > .75$. Therefore, the Huynh-Feldt correction to the degrees of freedom was chosen to account for the violation to the assumption of sphericity.

There was a significant main effect of phase, $F(1.79, 110.94) = 33.81$, $p < .01$, $\eta^2_p = .35$, such that performance tended to be highest at post-test. There was a significant main effect of age group, $F(1, 62) = 12.89$, $p < .01$, $\eta^2_p = .17$, such that younger adults tended to outperform older adults.

There were no significant interaction between phase and support group, $F(3.98, 123.24) = 1.51$, $p = .20$, $\eta^2_p = .05$. There was no significant interaction between phase and age group, $F(1.98, 123.24) = .08$, $p = .91$, $\eta^2_p < .01$. Last, there was no significant interaction between phase, support group, and age group, $F(3.98, 123.24) = 1.94$, $p = .11$, $\eta^2_p = .06$.

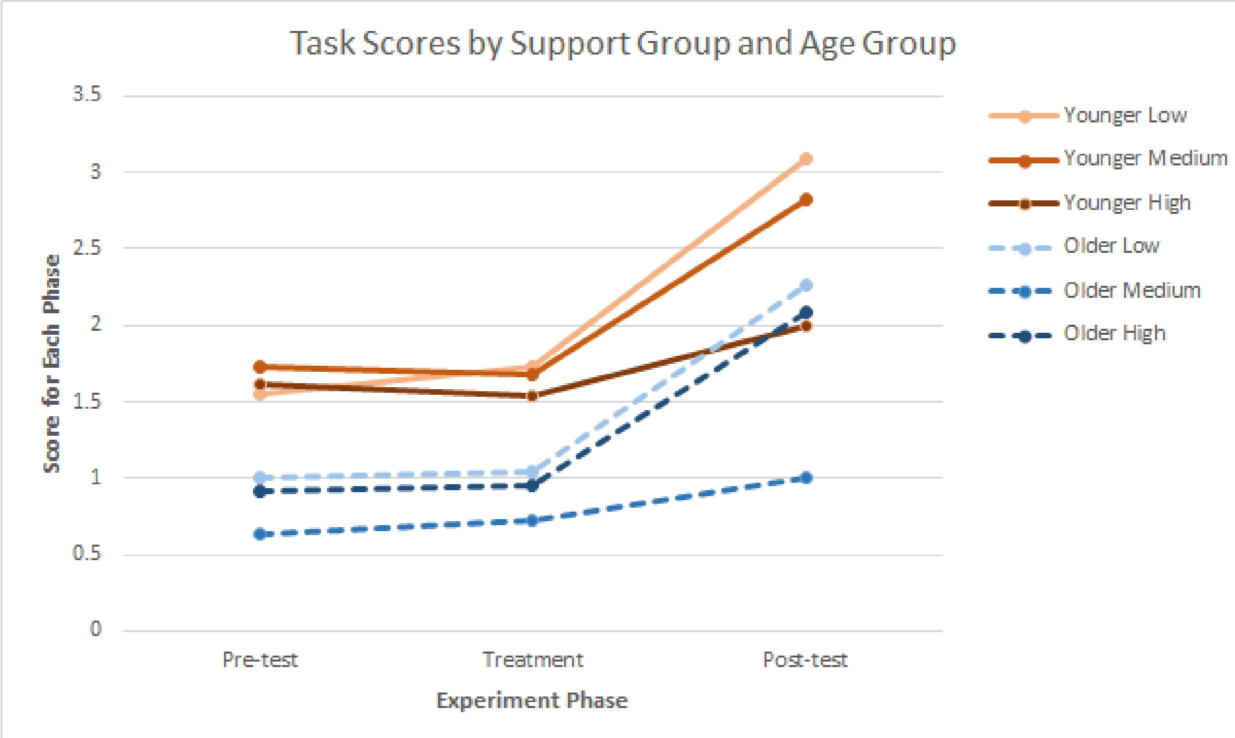


Figure 7. Task scores by support group and age group, across the three phrases of the experiment. Scores for the treatment phase were divided by two to account for the fact that participants completed twice as many questions during this phase.

Components of Decision Support. A series of one-way repeated measure ANOVAs were performed to compare the effect of the different components of decision support (Table 3) on learning, performance, and reliance. Because the low and medium support conditions received the same information acquisition support (highlighting - considered lower information acquisition support) and differed only on the inclusion of analysis support, it was possible to compare these groups to examine the effect of the inclusion of analysis support (i.e., the calculation for the participant of net carbs). Because the medium and high decision support conditions received the same information analysis support (i.e., calculation of net carbs) and differed only on the level of information acquisition support (i.e., whether labels were filtered to only show needed information) it was possible to compare these groups to examine the effect of increased information acquisition support.

Effects of information analysis. To examine the effect of the presence of information analysis support (i.e., net carb calculation) on task scores, analyses were conducted comparing the low support and medium decision support groups. Comparing pre-test and treatment scores for these two support groups examined the effect of information analysis support on task performance. Comparing pre- and post-test scores examined the effect of information analysis support on learning. Comparing treatment and post-test scores examined the effect of reliance on information analysis support.

Performance. A repeated measures ANOVA was performed to examine support group differences between pre-test and treatment phases. Treatment scores were divided by two to account for the fact that participants completed twice as many questions during the treatment phase as during the pre-test phase. The analysis found no significant effect of phase, $F(1, 42) = .31$, $p = .58$, $\eta^2_p = .01$, and no significant interaction between phase and support group, $F(1, 42) = .14$, $p = .72$, $\eta^2_p = .00$.

Learning. A repeated measures ANOVA was performed to examine support group differences between pre- and post-test phases. There was a significant effect of phase, $F(1, 42) = 33.11$, $p < .01$, $\eta^2_p = .44$, such that both support groups combined scored significantly higher during the post-test ($M = 2.30$, $SD = 1.46$) than during the pre-test ($M = 1.23$, $SD = 1.14$). There was no significant interaction between phase and support group, $F(1, 42) = 3.37$, $p = .07$, $\eta^2_p = .07$.

Reliance. A repeated measures ANOVA was performed to examine support group differences between treatment and post-test phases. Treatment scores were divided by two to account for the fact that participants completed twice as many questions during the treatment phase as during the pre-test phase. There was a significant effect of phase, $F(1, 42) = 39.61$, $p < .01$, $\eta^2_p = .49$, such that such that both support groups combined scored higher during the post-test ($M = 2.30$, $SD = 1.46$) than during the treatment ($M = 1.30$, $SD = .96$). There was no significant interaction between treatment phase and support group, $F(1, 42) = 3.46$, $p = .07$, $\eta^2_p = .08$.

Effects of information acquisition. To examine the effect of the presence of a higher level of information acquisition support on scores (i.e., filtering unnecessary information), analyses were conducted comparing scores between the medium and high decision support groups. Comparing pre-test and treatment scores for these two groups examined the supportive effect of information acquisition on performance. Comparing pre- and post-test scores examined the effect of information acquisition support on learning. Comparing treatment and post-test scores examined the effect of reliance on information acquisition support.

Performance. A repeated measures ANOVA was performed to examine support group differences between pre-test and treatment phases. Treatment scores were divided by two to account for the fact that participants completed twice as many questions during the treatment phase as during the pre-test phase. There was no significant effect of phase, $F(1, 44) = .00$, $p = .99$, $\eta^2_p = .00$, and no significant interaction between phase and support group, $F(1, 44) = .02$, $p = .89$, $\eta^2_p = .00$.

Learning. A repeated measures ANOVA was performed to examine support group differences between pre- and post-test phases. There was a significant effect of phase, $F(1, 44) = 16.01$, $p < .01$, $\eta^2_p = .27$, such that both support groups combined scored significantly higher during the post-test ($M = 1.98$, $SD = 1.42$) than during the pre-test ($M = 1.24$, $SD = 1.23$). There was no significant interaction between phase and group, $F(1, 44) = .00$, $p = .95$, $\eta^2_p < .01$.

Reliance. A repeated measures ANOVA was performed to examine support group differences between treatment and post-test phases. Treatment scores were divided by two to account for the fact that participants completed twice as many questions during the treatment phase as during the pre-test phase. There was a significant effect of phase, $F(1, 44) = 24.53$, $p < .01$, $\eta^2_p = .36$, such that both support groups combined scored significantly higher during the post-test ($M = 1.98$, $SD = 1.42$) than during the treatment ($M = 1.24$, $SD = .89$). There was no significant interaction between phase and support group, $F(1, 44) = .05$, $p = .83$, $\eta^2_p = .00$.

Levels of Decision Support and Age Group on Subjective Measures. A 3 x 2 factorial MANOVA was performed to examine the effects of the independent variables of level of decision support (low, medium, high) and age group (younger, older) on the dependent variables of subjective task experiences (Table 5). There was a significant main effect of age group on subjective performance, $F(1, 62) = 9.18$, $p < .01$, $\eta^2_p = .13$, such that younger adults reported better subjective performance than younger adults. There was a marginally significant main effect of age group on experiences of fatigue, $F(1, 62) = 3.84$, $p = .055$, $\eta^2_p = .06$, such that younger adults reported experiencing more fatigue than older adults. There were no significant main effects of support group on the other dependent variables, and no significant interactions between support group and age group.

Table 5. *The Effect of Decision Support Level and Age Group on Subjective Task Experience*

		Low Support	Medium Support	High Support	
Sample size	Younger	11	11	13	
	Older	11	11	11	
		M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Similar/different[1]	Younger	2.73 (1.68)	2.55 (1.57)	3.31 (.85)	2.89 (1.39)
	Older	2.27 (1.56)	2.82 (1.33)	2.36 (1.36)	2.49 (1.40)
	Total	2.50 (1.60)	2.68 (1.42)	2.88 (1.19)	
Difficult/easy: calories[2]	Younger	1.82 (1.17)	2.00 (.89)	1.77 (.83)	1.86 (.94)
	Older	1.82 (.87)	1.45 (.52)	1.73 (.91)	1.67 (.78)
	Total	1.82 (1.01)	1.73 (.77)	1.75 (.85)	
Difficult/easy: net carbs[2]	Younger	1.73 (.91)	1.73 (1.01)	1.69 (1.11)	1.71 (.99)
	Older	2.09 (.83)	1.73 (.47)	1.64 (.81)	1.82 (.73)
	Total	1.91 (.87)	1.73 (.77)	1.67 (.96)	
Difficult/easy: overall[2]	Younger	1.64 (.92)	1.45 (.82)	1.31 (.86)	1.46 (.85)
	Older	1.73 (.79)	1.27 (.47)	1.36 (.92)	1.45 (.75)
	Total	1.68 (.84)	1.36 (.66)	1.33 (.87)	
Tiring/fatiguing[3]*	Younger	2.00 (1.18)	2.18 (1.17)	2.15 (.90)	2.11 (1.05)
	Older	2.64 (.92)	2.45 (1.13)	2.73 (.91)	2.61 (.97)
	Total	2.32 (1.09)	2.32 (1.13)	2.42 (.93)	
Subjective performance[4]	Younger	1.36 (1.03)	1.09 (.83)	1.85 (.69)	1.46 (.89)
	Older	2.00 (1.00)	2.09 (.70)	2.09 (.83)	2.06 (.83)
	Total	1.68 (1.04)	1.59 (.91)	1.96 (.75)	

Note: All responses on a 5-point scale

* Indicates a significant effect of age group at $p < .01$

[1] Lower scores indicated greater perceived similarity to past experience

[2] Lower scores indicated greater perceived difficulty

[3] Lower scores indicated greater perceived difficulty

[3] Higher scores indicated greater perceived fatigue

[4] Higher scores indicated worse peceived performance

Study 2 - The Type and Nature of Support on a Diabetes Internet Forum

Method

Data Selection

We collected data from a large forum dedicated to the discussion of type 2 diabetes. The forum contained over 200,000 posts made over a five year period. We implemented a semi-random sampling procedure to increase the likelihood of analyzing a representative sample of forum posts. We selected two initial samples containing 275 posts each, one from May 2013 and one from November 2013. Random selection was then used to select 50 posts from each time point for analysis, for a total of 100 posts selected for inclusion in the final sample.

Coding Process

The 100 selected first posts were independently coded by two trained coders. Only the first post in a discussion was included in the analysis and not replies to the initial post, although replies were retained for examination as part of a future study. After separately coding a batch of posts the coders met to discuss the codes used and resolve any disagreements in the initial coding. Disagreements were recorded along with the final agreed upon list of codes for a post, and the coding scheme was updated iteratively to reflect any necessary modifications to better classify posts.

Some codes were generally straightforward to apply to the text. For example, deciding whether the code "Atkins diet," which was a sub-code under the codes of "diet" and "specific diet," applied to a post. However, other posts required more careful consideration because they either dealt with more abstract concepts, e.g. different types of informational support, or they required a degree of interpretation by the coder, e.g. implied emotions. A set of classification distinctions were developed to address these considerations.

Classification Distinctions

The illustrative examples given below for each classification are paraphrased versions of quotes from actual coded posts used in the study. Although the forum is public, to help protect users' privacy the content of each example was reworded from the original quote before it was included in this document. Every attempt has been made to preserve the main ideas expressed in the original quote.

Advice and Teaching. Informational support provided or requested in a post could take different forms, and the distinction between the codes of advice and teaching was particularly important. The advice code was used if both A) a user was requesting or providing information, and B) there was a reasonable suspicion that a user might act on the information. A post by a user wanting to know what supplements she should take to prevent kidney damage, for example, would be coded as a request for advice. In this case the user is asking about an action (taking supplements) that she could take to achieve a goal (preventing kidney damage). The "contact healthcare provider" sub-code of advice was used when the advice was to visit or contact a healthcare provider (provision) or when the post was soliciting advice about when to contact a healthcare provider or which provider to see (request).

By contrast, the teaching code was used if A) a user was requesting or providing information, and B) there was not a reasonable suspicion that a user might act on the information. The information was being provided or requested with the intent to inform or educate, and not to guide behavior. A post by a user wanting to know how high blood glucose damages the kidneys, for example, would be coded as a request for teaching. In this case the user is interested in how something works, but the nature of the request does not lead to the reasonable suspicion that any action will be taken on the basis of the information.

These initial codes will ultimately serve more intensive future coding efforts. Posts coded with advice, for example, can be examined in a future study to determine if the information being shared on the forum could be described as laypersons giving medical advice. Posts coded with teaching could be examined to determine the topics or kinds of conceptual information users of the forum might be struggling to understand, and how that information may or may not overlap with the informational content typically provided by certified diabetes educators.

Illustrative Example: Advice. "I have type 2 diabetes, and I have a problem. Every time I attempt to eat right my sugar goes low and I go eat things with sugar. I'm afraid my sugar will drop too low and I won't be able to treat it, so I eat sugar food to try to keep it up. Does anyone have any suggestions to help me?"

The original quote represented by this example was coded as "advice." The user was concerned about low blood glucose after eating, and as a result had been eating particular foods ("sugar food" – possibly food items high in grams of sugar or carbohydrates, or products like glucose tablets designed to treat low blood sugar). The post ends with a request for suggestions, and it was reasonable to assume that the user might act on the basis of the information provided.

Illustrative Example: Teaching. "On some posts I saw an abbreviation for blood sugar and for blood glucose. Those are the same things, right? Or am I wrong??"

The original quote represented by this example was coded as "teaching." The user was uncertain if the terms "blood sugar" and "blood glucose" are referring to the same concept and was requesting informational support. The intent was to become more informed and to clear up a point of confusion, and there was no reason to expect the user would act on the information once it is provided.

Describing Experience. Another type of informational support present on the forum involved sharing one's experience or requesting the experiences of others. For a post to be coded as the "describing experience" type of informational support, the user must have either A) provided her own experience with the intent of informing other (provision), or B) requested information in the form of others' experiences (request).

Illustrative Example: Describing Experience: "The other day I had a follow-up and I was told my right eye is stable, and my left eye is considered slightly proliferative. I will likely get additional laser treatment on the other eye. Here's my question if anyone knows or has experienced this - I know it can always return, but has anyone had laser treatment or knows someone who did who was fine?"

The original quote represented by this example was coded as "describing experience – request." The user is seeking information from others who have experienced laser therapy for the treatment proliferative diabetic retinopathy; specifically, she wants to know if anyone has had good outcomes after undergoing the laser therapy.

Symptoms and Side Effects. When users post about health symptoms they are experiencing it can be unclear whether the symptom is related or unrelated to diabetes. In some cases, the user may not be aware that a symptom they describe is a side effect of diabetes, or may falsely believe a symptom is due to their diabetes. Our litmus test for determining whether a symptom or side effect was associated to diabetes was the information about diabetes complications and related conditions on the website of the American Diabetes Association (ADA, 2015). If the symptom described by the user was listed on the site, it was coded as a symptom or side effect of diabetes. If it was not, it was coded as "Other Health – Symptoms." In cases where a user describes a vague symptom that could be considered either related to diabetes or unrelated to it, the preference was to err on the side of coding it as unrelated to diabetes.

Illustrative Example: Symptoms or Side Effects of Diabetes. "Does anyone get specific areas of skin on your hands that that gets dry? Every few weeks one finger on my right hand gets dry and peels at the tip of the finger, to the point that the skin cracks or almost does. Also the skin of another finger is dry and "scaly."

The original quote represented by this example was coded as a symptom or side effect of diabetes because the ADA website's section on skin care states "People with high glucose levels tend to have dry skin" (ADA, 2015).

Illustrative Example: Symptoms or Side Effects Unrelated to Diabetes. "I've been eating a low carbohydrate diet ever after I was diagnosed back in August. As a result I get a lot of protein and a relatively high amount of fat in my diet. I get stomach discomfort, and it can be like my digestive system seems to hate me."

The original quote represented by this example was coded as a health symptom unrelated to diabetes. Stomach discomfort is not inherently associated with diabetes. Although a tenuous connection could be argued if one considers stomach discomfort as a side effect of gastroparesis, which is a potential complication of diabetes and is listed on the ADA website, there was no clear evidence that this instance of stomach discomfort was in fact associated with gastroparesis.

Interaction of Non-Diabetes Illness and Diabetes. Sometimes the management of diabetes may become complicated by other health conditions that either directly interact with diabetes or its treatment, or require medications that do. For example, many health conditions unrelated to diabetes are treated with corticosteroids such as prednisone. Prednisone affects glucose metabolism and can raise blood glucose, particularly among persons with diabetes who are more likely to experience elevated blood glucose already.

When a non-diabetes illness, condition, or medication was mentioned, we examined the post for one of two potential criteria. Either 1) there was a known association between the illness, condition, or medication and diabetes or the medications used to treat it, or 2) the user suspected or posited an association between the illness, condition, or medication and diabetes or the medications used to treat it. If either criterion was met, we coded the post as an interaction of non-diabetes illness and diabetes.

Illustrative Example: Interaction of Non-Diabetes Illness and Diabetes. "My blood glucose rises to unhealthily high levels when I take a medication, Adderall 20mg. Anyone have any ideas why?"

The original quote represented by this example was coded as interaction of non-diabetes illness and diabetes because the user described a medication not used to treat diabetes (Adderall) and suggested an observed effect where taking the medication resulted in elevated blood glucose.

Problem Solving. The problem solving code was developed to identify posts, and likely replies, that could be examined in a future study to better understand the problem solving processes involved in diabetes-self management. This code was used if either the user was trying to solve a problem within their post, which could be directly examined, or they posed a problem and asked for others' help to solve it. In this latter scenario, even if the initial post did not contain problem solving behavior, the subsequent replies could later be examined to better understand collaborative problem solving on the forum.

Illustrative Example: Problem Solving. "I'm having problems with my stomach because of my low carb diet, which has a lot of protein and fat. Anyone else have this issue? What helps you? My idea is to occasionally "cheat" on my diet and eat some fiber cereal with yogurt and blueberries or something else with a lot of fiber."

The original quote represented by this example was coded as a request for problem solving. The user posed a problem – stomach discomfort – and a believed cause underlying the problem – a low carbohydrate diet with high protein and fat content – and asked for help. Based on the interpretation of the problem and its cause, the user also suggested a potential solution that might be attempted: "cheating" on a low carbohydrate diet by adding fiber, potentially a fiber-rich cereal, berries, and yogurt.

Emotional Expression. Coding text for emotional content involves examining not only overtly stated emotions but also more subtle expressions where an emotion is not specifically stated but could be inferred from the content of the post. While automated text analysis would be sufficient for the former situation, given a sufficiently-sized dictionary of emotion words, the more subtle expressions of emotion required a more careful look. It was important to capture the less straightforward emotional expressions because only coding the explicitly stated examples would understate the level of emotional content on the forum.

Stated Emotions. These codes involved a direct statement of an emotion, e.g. "I am happy," or "It makes me so mad!" Words that described the same approximate emotion, e.g. "concern" and "worry," were also coded as stated. In cases where the user expressed emotion that did not fit the preexisting classification of emotions or could not be categorized, the post was coded with either "emotional expression – positive" or "emotional expression – negative" to capture the valence of the stated emotion.

Illustrative Example: Stated Emotions: "Okay, this situation has me completely befuddled. My blood sugar is lower AFTER I eat than it is before a meal. 145 before a meal and 117 when I measure one hour after I eat. I normally peak at an hour. This does not make sense. Can anyone provide any help?"

The original quote represented by this example was coded as stated confusion because the user directly stated that a situation "has me completely [befuddled]." Here, the emotion of being "befuddled" is considered similar enough to the emotional experience of being confused and it is therefore coded as "confusion."

Implied Emotions. These codes involved more subtle expressions of emotion. Even if a post lacked words that directly referenced an emotion, emotional expression might still be inferred from the use of punctuation, emotional icons known as "emoticons" or "emoji," or from an overall emotional tone to the post. Like with stated emotions, in cases where the user expressed emotion that did not fit the preexisting classification of emotions or could not be categorized, the post was coded to capture the valance of the implied emotion.

Illustrative Example: Implied Emotions: "I see that some of the posts on the forum gave an abbreviation for blood sugar and blood glucose. Those are the same things, right? Or am I off??"

The original quote represented by this example was coded as implied confusion because of the inclusion of the double question marks at the end of the last sentence. The presence of a question is not enough to infer the presence of confusion – it is possible to ask a question without feeling or expressing confusion – but the use of double question is an indication that there is emotion associated with this post. Double question marks could be associated with another emotion, like surprise or anger, but because the user asks "or am I off??" we can reasonably assume that the implied emotion is confusion.

Results

Inter-Rater Reliability

The reliability of coding between the two raters was calculated by the percent agreement method. Each code for a post represented a binary opportunity for agreement or disagreement between coders. If coders independently decided to both include or exclude a code for a post, this constituted an instance of agreement. If only one coder independently decided to include a code, or the coders used two different codes to label the same content in a post, this constituted an instance of disagreement. Occasions where the two coders chose similar but distinct codes, e.g. implied anger vs. stated anger, were coded as a disagreement.

The percent agreement score was calculated by the number of agreement scores divided by the total number of scores. Percent agreement has been criticized for failing to account for chance agreement (Cohen, 1960). However, because of the number of codes in the scheme it was unlikely that agreement on particular code would result by chance.

After resolving any disagreements, each post was assigned a mean of 10.97 codes (Figure 8; SD = 5.78) of out of a total possible 234 codes in the scheme. There was a mean of 3.28 disagreements (Figure 9; SD = 2.17) per post. This represents an overall mean percent agreement of 98.60% (SD = .93%). Linear regression analysis found no association between the coding order and the number of codes assigned to the a post, $F(1, 98) = 1.31$, $p = .26$, $R2 = .01$, or between the coding order and the number of disagreements, $F(1, 98) = 3.34$, p = .07, R2 = .03. This suggests that consistent coding was maintained during the coding process.

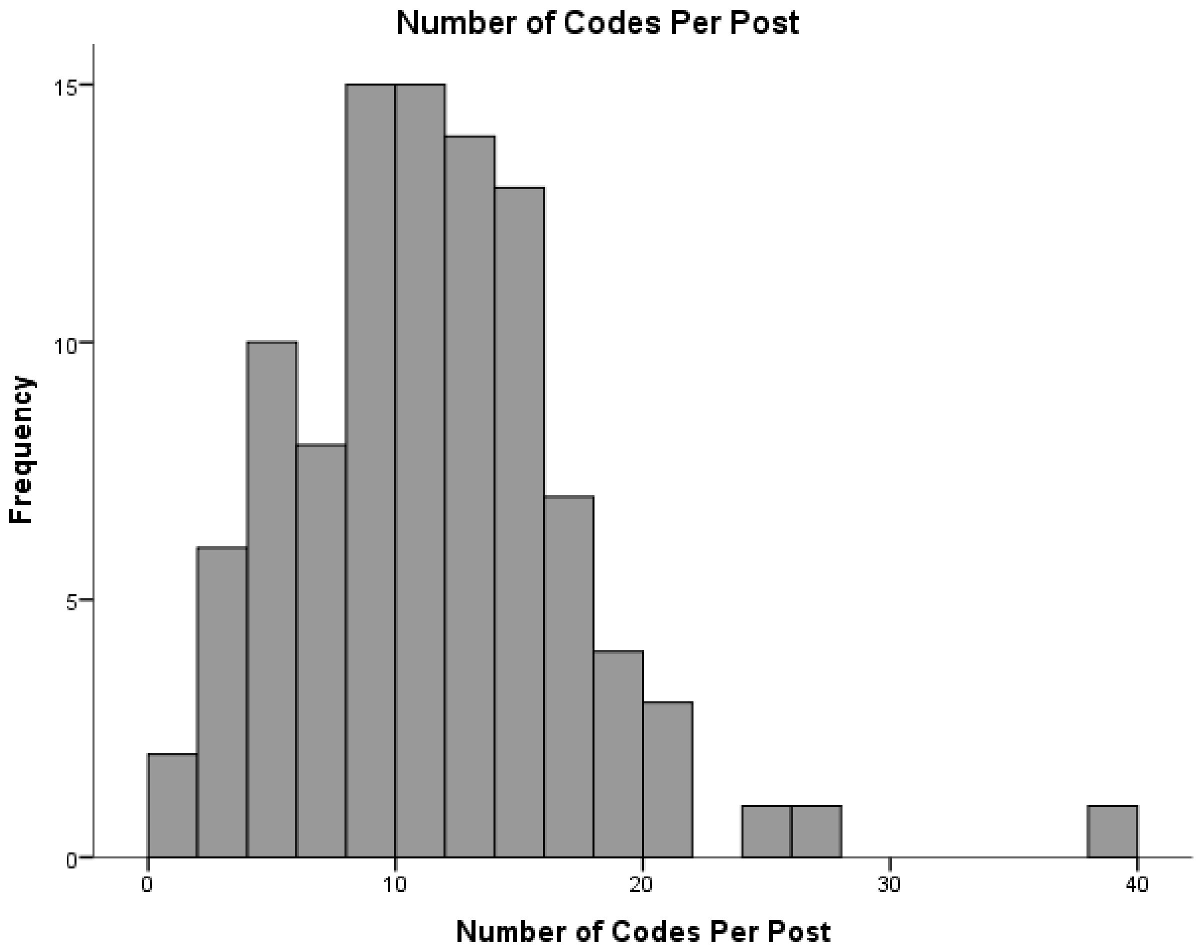


Figure 8. Number of codes assigned per post after discussion and agreement.

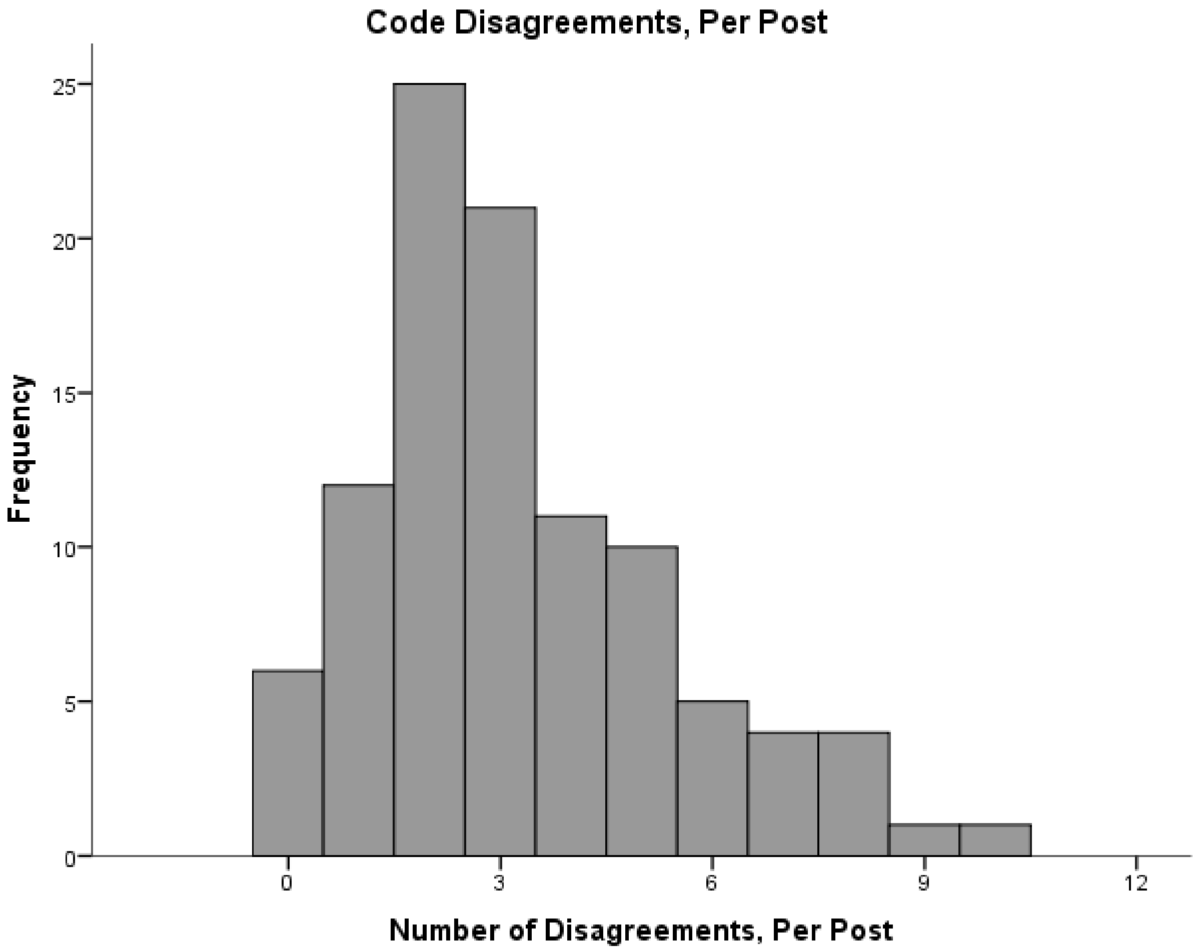


Figure 9. Number of disagreements per post, before discussion and agreement.

Topics

We examined the frequency of five broad categories of topics relevant to diabetes self-management behavior – diet, exercise, medication, healthcare visits, and equipment and technology – to determine which were most discussed on the forum in the 100 coded posts (Figure 10). Categories were not orthogonal. A single post could be coded into more than one category.

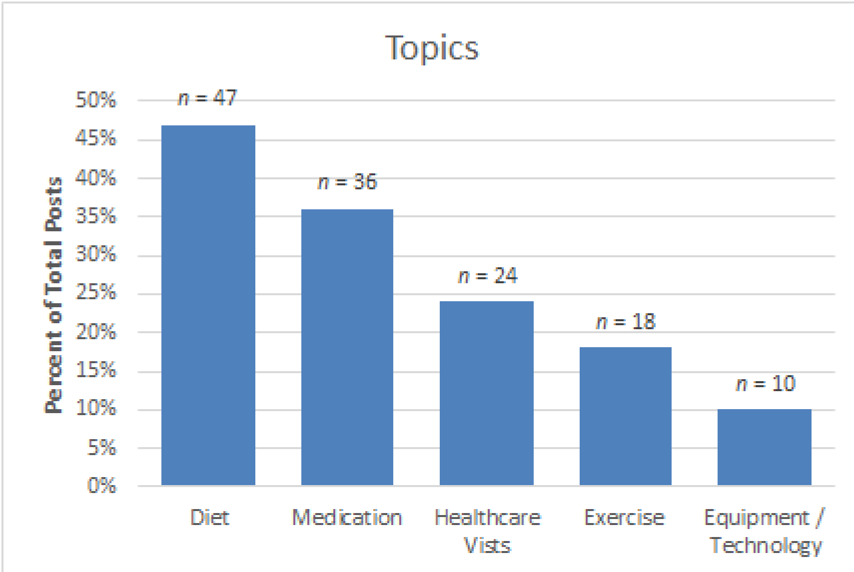


Figure 10. Posts per topic. The number of posts that mention or discuss a topic.

Diet. Dietary issues were the most commonly mentioned topic, with nearly half of all posts containing some reference to diet or food (n = 46). Of the posts that referenced diet or food, specific diets (e.g. a low carbohydrate diet), dietary difficulties, and carbohydrate counting were discussed the most frequently, followed by calorie counting and eating out (Figure 11).

Given the large number of posts that dealt with dietary issues, a successful automated system should address issues related to dietary self-management and nutritional concerns. For example, the system might assist the user to monitor and maintain appropriate carbohydrate intake, a recommended component of nutrition therapy for adults with diabetes (Evert et al., 2014). Over one quarter (n = 13) of all dietary posts referenced carbohydrate counting or a low carbohydrate diet, suggesting that users of the forum have already adopted this approach to dietary management in diabetes, or are at least aware of it.

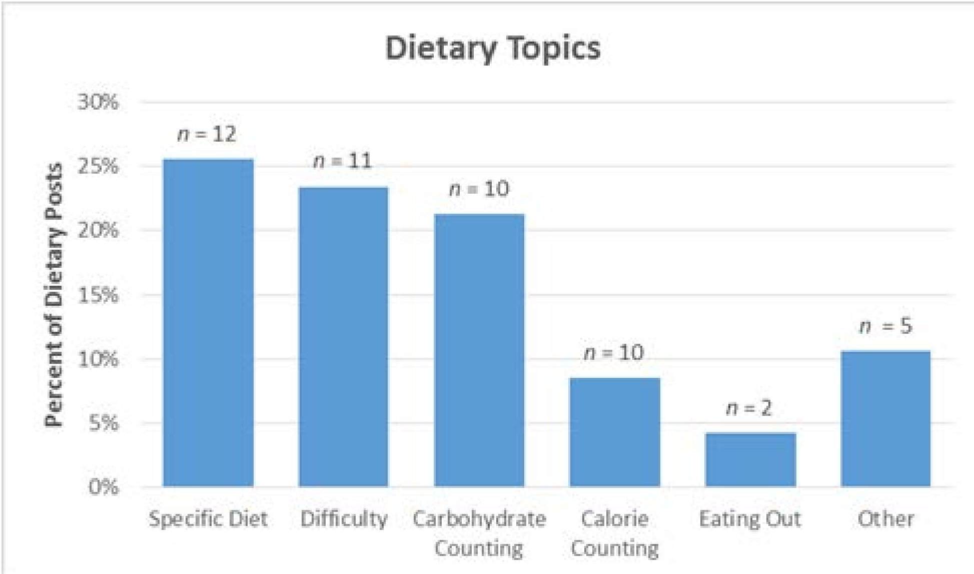


Figure 11. Dietary posts by dietary topic. The proportion of posts coded with "diet" that mentioned specific dietary topics. Note that posts could be coded with more than one topic.

Medication. Medication was the second most commonly mentioned topic, with over a third of posts mentioning some type of medication (*n* = 36). Of the posts that mentioned medication and could be further classified by type of medication (Figure 12), the majority discussed ones used for treating diabetes, and a smaller proportion discussed a medication used for the treatment of an illness or condition other than diabetes. Oral antihyperglycemic agents were mentioned more than insulin, and topics relating to the use of medication were discussed as well, including a previous or potential change to a medication, side effects, safety, and requests or provisions of recommendations for medication (Figure 13).

Although oral antihyperglycemic agents (e.g., Metformin) were mentioned more frequently than insulin, the frequency with which both types were mentioned suggests that an automated self-management support system should support the processes required for each.

For example, a system could address the prospective memory demands necessary for taking oral medications as scheduled, and also promote the user's capacity to detect and respond to hypoglycemic episodes that may result from insulin use but are less likely to occur with oral antihyperglycemic agents.

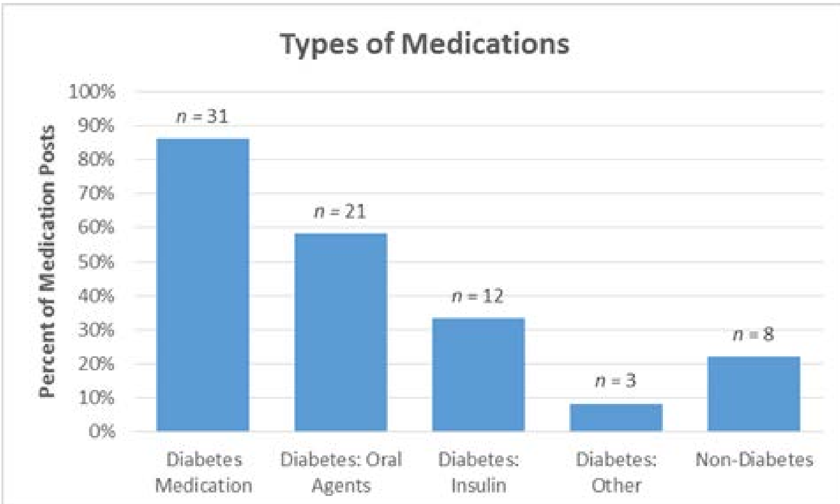


Figure 12. Medication posts by medication topic. The proportion of posts coded with "medication" that mentioned specific types of medications.

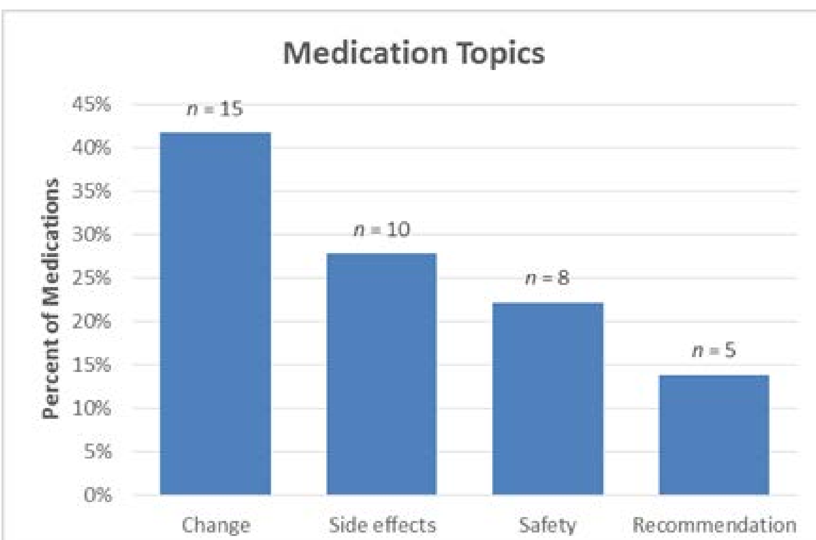


Figure 13. The proportion of posts coded with "medication" that mentioned specific topics related to the use of medication.

Healthcare Visits. Another common topic was visits to healthcare professionals or facilities, with about a quarter of posts referencing a visit (*n* = 24). The majority of healthcare visit posts centered around diabetes (Figure 14). A smaller proportion mentioned visits for an illness or condition unrelated to diabetes, a surgical procedure, a hospital visit, or an emergency room visit.

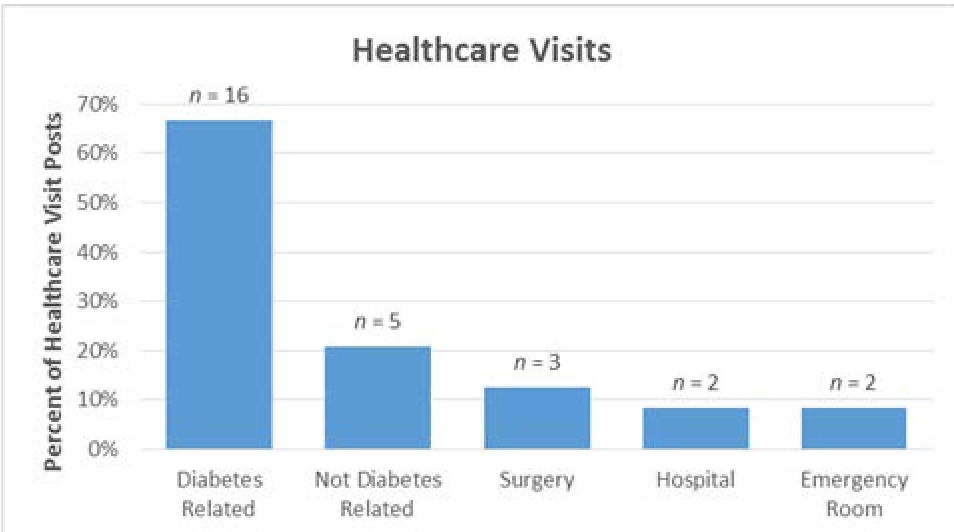


Figure 14. Healthcare visit posts by healthcare visit topic. The proportion of posts coded with "healthcare visit" that mentioned specific types of visits.

Exercise. Roughly one-fifth (*n* = 18) of posts mentioned exercise or physical activity. Of those posts that could be classified by topic, one-third discussed an exercise routine, while a couple requested provided an exercise recommendation or discussed a difficulty related to exercise (Figure 15).

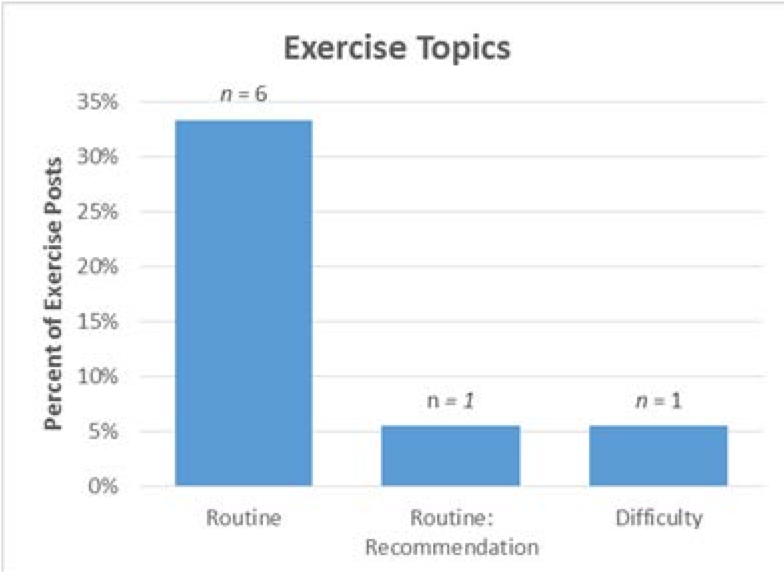


Figure 15. Exercise posts by exercise topic. The proportion of posts coded with "exercise" that mentioned specific topics related to exercise.

Equipment and Technology. A relatively small number of posts (*n* = 10) discussed some type of equipment or technology related to diabetes (Figure 16). Most commonly mentioned were insulin pens, followed by test strips and one reference to a glucometer. Note that simply mentioning testing one's blood glucose was not enough to qualify as a mention of glucometer equipment; to be coded with "glucometer," the post was required to mention the meter specifically.

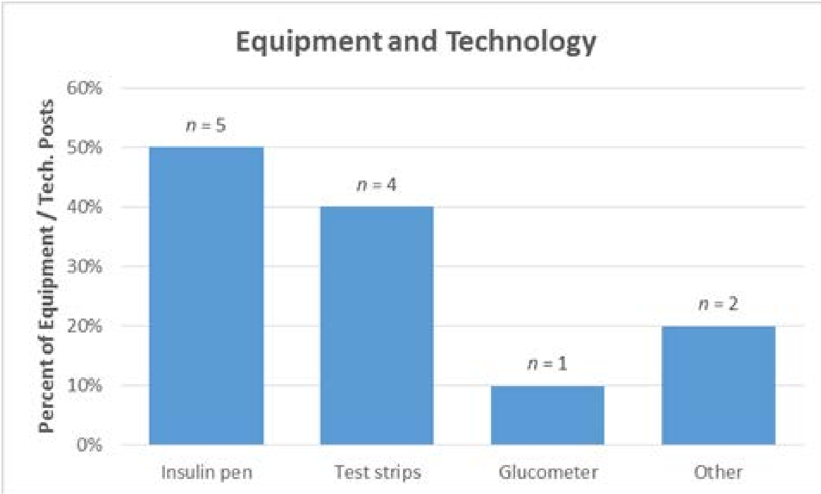


Figure 16. The proportion of posts coded with "equipment and technology" that mentioned specific types of equipment or technology.

Informational Support

Sharing informational support related to diabetes and its management was a common theme on the forum. Two-thirds (*n* = 66) of posts on the forum either requested (*n* = 51) or provided (*n* = 17) informational support. This was likely due to looking at first posts. Subsequent replies would be more likely to provide informational support to another user's request.

Requests. Requests for informational support are particularly relevant to the design of decision support to support diabetes self-management because they represent what users want to know - and potentially what they need to know - to support them in diabetes self-management. The most commonly requested form of informational support was advice, followed by descriptions of others' experience, and teaching (Figure 17).

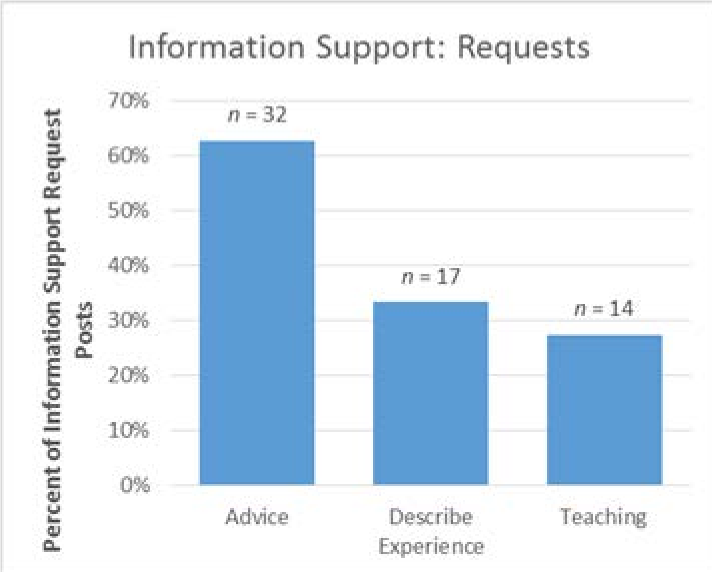


Figure 17. Informational support requests by type.   Requests for the different types of informational support, as a percent of the total number of posts requesting informational support.

Requests: Advice. Posts requesting advice constituted 63% of all posts requesting information. Advice was distinguished from other forms of informational support by a reasonable expectation that the user might act based on the information received.

Illustrative Example: Requests: Advice (A). "I'm having such a hard time keeping my weight off and I just can't see a way to get back on track!! I have type 2 diabetes and I haven't been taking medications, since I lost weight, but I don't want to have to start taking them again! Would be grateful for any help!!"

Here (A) the poster is concerned about regaining lost weight and is asking for help from other users to avoid weight gain, and consequently to avoid having to resume medication for diabetes. Other users might provide strategies or suggestions to help maintain weight loss and the poster may change behavior based on the advice. Because of the interactive nature of internet forums, advice can be tailored to an individual's particular situation. If not enough details are provided in the initial post, users replying can solicit additional details until they feel they can provide advice that is tailored to the particular person and circumstances.

As noted in the national standards for diabetes self-management education and support (Haas et al., 2014), individualization is an important component of effective education and support. Because the individual with diabetes must turn knowledge about diabetes self-management into actions that fit with her lifestyle, ideal advice must take into account details about the user, her characteristics, her preferences, and her needs. While a level of interactivity like that on an internet forum might be difficult to incorporate into an automated decision support system, certain aspects of a support system could give advice tailored to an individual. For example, dietary advice could be adjusted based on an individual's carbohydrate tolerance and personal preferences.

Illustrative Example: Requests: Advice (B). "As my morning meal I eat two pieces of bacon (well-done) and two eggs. I measure my blood sugar two hours after I eat and it's a spot-on 100 but if I have anything else, like oatmeal or a breakfast burrito it's at least 170. I eat this a lot but I'm getting bored."

In this example (B) from a post coded as advice, the poster is having trouble finding foods that do not result in an elevated blood glucose. Through testing, he or she knows that a specific meal – two pieces of bacon and two eggs – results in an ideal blood glucose reading two hours later. However, other specified foods – oatmeal or a burrito – have caused the blood glucose to rise too high. An automated decision support system could use logged data from the user's previous meals and blood glucose readings to predict the carbohydrate limit the user can tolerate. Then, it could give suggestions for foods or entire meals that would fit within this limit and also appeal to the user, based on user preferences or records of what the user already eats.

Requests: Describe Experience. Around one-third of posts requesting informational support asked about the experiences of other users.

Illustrative Example: Requests: Describe Experience (A). I'm curious, anyone else having any luck getting their A1C down with Victoza? I'm on day 2."

In this example (A) from a post coded as a request for describing experience, the poster wants to hear from other users who are also taking the medication Victoza. In daily life the user may or may not know anyone with diabetes, or anyone who has taken the medication. On the forum, however, such a request is very likely to find others who have taken the medication and can share their experiences. Asking for others' experiences also opens up the possibility of receiving more information than simple success rates, which is information that could be provided by one's doctor or a pamphlet accompanying the medication. Do other people who have tried the medication like or dislike it? Has anyone tried it and then moved on to a better medication? What might someone who has experience with the medication want to share with someone who is new to it? These are questions that are better answered by other people, not by a pamphlet or book.

Illustrative Example: Requests: Describe Experience (B). "Okay, I've finally accepted that I really have diabetes and that it won't go away. Should I consider getting and wearing one of those diabetes alert medical bracelets? Anyone wear one? If you do, where can I buy one?"

Requests for others' personal experiences could overlap with requests for advice in cases when a user solicited others' opinions to guide his own behavior, as in the above example where the poster wants to know about the experiences of others who wear a medical alert bracelet for diabetes. In this example (B) from a post coded as a request for descriptions of experience there are several implicit and explicit questions. Should I indeed wear a medical alert bracelet? Does anyone else wear one, and what are your experiences with them? Where did you buy yours? The quality of any advice given in response to this post might be evaluated on the basis of the responder's stated experience. For example, a user with personal experience with medical alert bracelets might be judged a more trustworthy source than a user whose knowledge of them is limited to the abstract or impersonal.

While a decision support system cannot replace the role of humans sharing experiences with each other, it could be designed to allow users to connect with others who are like themselves and who have the experiences they seek. Users could fill out a profile of information that would allow the system to automatically match them with others. Although not all users of a decision support system would be willing to disclose information about themselves that would facilitate an automated matching system, we think it is likely that a significant number would. In the posts we examined many users were willing to disclose specific details about their personal and medical histories in the interest of connecting with and helping others. In fact, some even use an automatic "signature" that appends details like their date of diagnosis, A1C, and weight to every post they make on the forum. These details, along with personal characteristics and preferences, could be used to create an automated matching system to facilitate experience sharing between users.

Requests: Teaching. Posts containing a request for teaching constituted 27% of all posts requesting information. Teaching requests often took the form of "how" or "why" questions, with the poster asking other users to explain a concept, phenomenon, or term.

Illustrative Example: Requests: Teaching: "I'm curious but the patient info booklet they gave me doesn't give the answer. How long is it until the metformin in a dose has been released?"

The above example was taken from a post coded as a request for teaching. The poster wants to know how long it takes for a slow release form of metformin, an oral antihyperglycemic agent, to be released. Here, the forum acts as a supplement to information the poster has received through traditional channels; in this case, the channel is a legally mandated information booklet distributed alongside a prescribed medication. The information provided with the medication did not address the question, or did not address it sufficiently, and so the poster seeks information from other persons with diabetes who may know the answer. As with information given in response to requests for advice, once again the poster must evaluate the quality of the information received in any replies.

Provisions. Although not as frequent as posts requesting informational support, a number of posts initiated a discussion by providing informational support. In contrast to the requests, provisions were less likely to take the form of advice, and more likely to take the form of describing one's own experience or teaching (Figure 18).

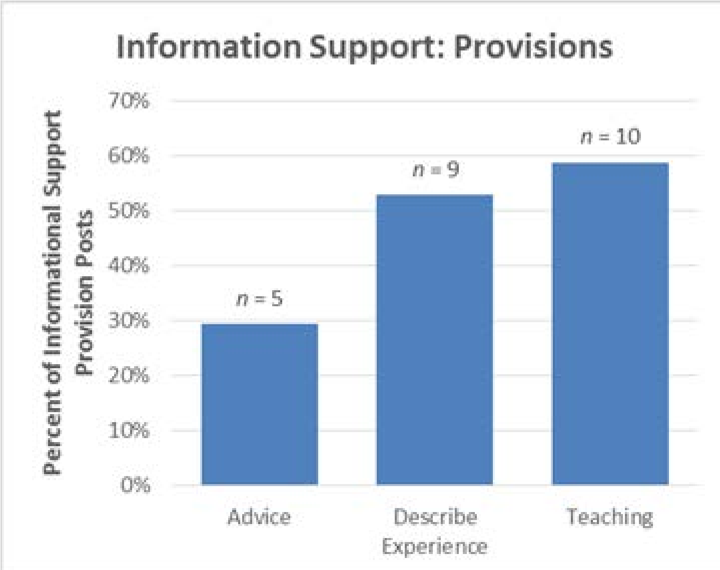


Figure 18. Informational support: provisions by type. Provisions of different types of informational support, as a percent of the total number of posts providing informational support.

Provisions: Advice. A minority of the total posts contained a provision of advice (n = 5), although nearly one third of posts providing informational support took the form of advice. Because we only examined first posts and not replies, the advice posts in this category were not in response to any particular person or situation. They tended to take the form of general advice, as in the following excerpt where the poster gives the unsolicited and general advice to "control carbs," "exercise," and "eat good."

Illustrative Example: Provision: Advice. "You got to keep your carbs down or nothing will change. Add in exercise and the sky's the limit! I fixed my body being diabetic for over a decade by having a strict diet and exercising. I lost more than 50 pounds. You need to eat good!"

The general nature of the advice given in posts of these nature make them more similar to advice for persons with diabetes that might be found on a personal website or blog. In some cases, the advice was given in a form of an article copied from another website with a link so users could visit the article.

Provisions: Describe Experience. Over half of posts that provided informational support included a description of personal experience, often in the form of success stories.

Illustrative Example: Provision: Describe Experience. "I was drawn to this book because growing up I had a father who was against medications, if you didn't need them. I thought "WOW, Dad to save the day!" I bought the book and began reading it and it was impossible to put it down. I started the program from the book and now it's January and I've lowered my weight from 254 to 209. My A1c three months ago was 6.3. I don't need any of my medications anymore except the one to keep my blood pressure low. Last month my doctor even had me stop taking that one and now I don't take any medications."

In this example, taken from a quote coded as a provision of describing experience, the poster shares details about what led to personal success in weight loss and blood glucose control. It was not uncommon for posters describing their experience to share specific details of their medical history. In this case the user discloses medication usage, body weight, and the lab value A1c, which provides information about the average blood glucose level during the recent past. Other users sometimes offered information about other health conditions or diagnoses, cholesterol, and medical events such as a surgery or heart attack.

Provisions: Teaching. Posts containing teaching (n = 10) sought to inform other users in a general sense, although some also provided advice or a description of personal experience. In the excerpt below the poster sought to educate others about the risk of cardiovascular disease associated with diabetes, and about procedure in which a stent is inserted into a coronary artery to improve blood flow and protect the artery.

Illustrative Example: Provision: Teaching. “If your diabetes isn’t under control, and it goes on for a long time, either high blood sugar or an aggressive type 2 diabetes then seeing a cardiac specialist is a good idea. This is because your heart likely has plaque building up in it and if they find it before your heart is fully blocked, you can get a stent. A stent is an outpatient procedure that quickly resolves symptoms, the recovery is very quick (hours), and pain is low. But if a full blockage happens then you have a heart attack or stroke and even if you survive, you will probably have some disability from it.”

The above example was taken from a post coded as a provision of teaching. Here, the poster provides the information in his or her own words, although sometimes posters provided information obtained directly from other sources. These posts (n = 3) took the form of articles copied from or linked to another source, ranging from an article in popular media (e.g. Yahoo!) to an article in a scholarly journal (e.g. The New England Journal of Medicine). The posters sometimes provided their own commentary on the article as well.

Teaching delivered by a decision support system could be adjusted based on user characteristics like health literacy, numeracy, prior knowledge, and interest level. For example, a user with high health literacy but low interest must benefit from fewer instances of teaching than a user with low health literacy but high interest. Advanced systems could even estimate the user’s diabetes knowledge or other relevant characteristics via their interactions with the system, and tailor the delivery of information accordingly.

Emotional Support

Beyond fulfilling users' informational needs, the forum also served as a place for users to provide and receive emotional support. Because we only included first posts in the analysis we do not have support coded in responses to first posts. However, some first posts contained emotional support, both providing (n = 11) and requesting (n = 6) it. Because these were first posts, the emotional support provided tended to be general in nature, addressing readers of the forum as a whole as in the example (A) below.

Illustrative example: Provision: Emotional Support. "Now I eat the way I should, work out for at least an hour a day, and my lifestyle is a lot healthier! I will live a longer life because of this. If this is something I can do, I KNOW YOU CAN DO IT TOO!"

In this example taken from a post coded as a provision of emotional support, the user offered him or herself as a success story to motivate others, and provided explicit encouragement by saying that such success is possible for the readers of the post as well. As noted in the national standards for diabetes self-management education and support (Haas et al., 2014), an important component of effect support for diabetes self-management is psychosocial support. The individual with diabetes must incorporate varying degrees of changes into his lifestyle, from giving up favorite foods to increasing physical activity to taking a daily medication that may have unpleasant side effects. The knowledge of what to do alone is not enough.

Illustrative Example: Request: Emotional Support. "I was given my diagnosis of diabetes about 2.5 months ago. A week or so ago I fell off the wagon but today is my third day of being careful with my carbohydrates and calories again. My doctor has me on a daily limit of 2000 calories and 175 carbs. Yesterday, I ate well and also went on a walk and did my yardwork for an hour. Today, I ate well again, walked for a mile and a half and went on an extra walk with my dog. I tested my blood glucose three times per day like I'm supposed to. I'm sorry for the lengthy post, but I just came across this forum and I need the accountability! Thank you for reading."

In this example taken from a post coded as a request for emotional support, the poster expressed the struggle he or she had managing diabetes, but then continued with a list of recent successes including eating according to the doctor's plan, engaging in physical activity, and monitoring blood glucose. The user apologized for the long post but explained that the accountability of posting and engaging with others is helpful, and thanked the other users for reading. While the poster does not explicitly request encouragement or affirmation, the implicit message is a request for emotional support from other users.

Emotional Expression

Posts contained expressions of positive (*n* = 16) and negative (*n* = 33) emotions, both directly stated and implied by the overall tone of the post. Positive emotions included happiness, excitement, and pride, while negative emotions included worry, fear, confusion, sadness, anger, and stress (Figure 19). The greater frequency of emotional expression of negative emotions compared to positive emotions likely related to the topic of the forum: a chronic illness with potentially severe side effects, the management of which can be challenging and frustrating. Furthermore, as seen by the number of posts soliciting advice, many users created a new post to seek help for a problem or difficulty they were experiencing which is more likely to be associated with negative emotions like worry or frustration.

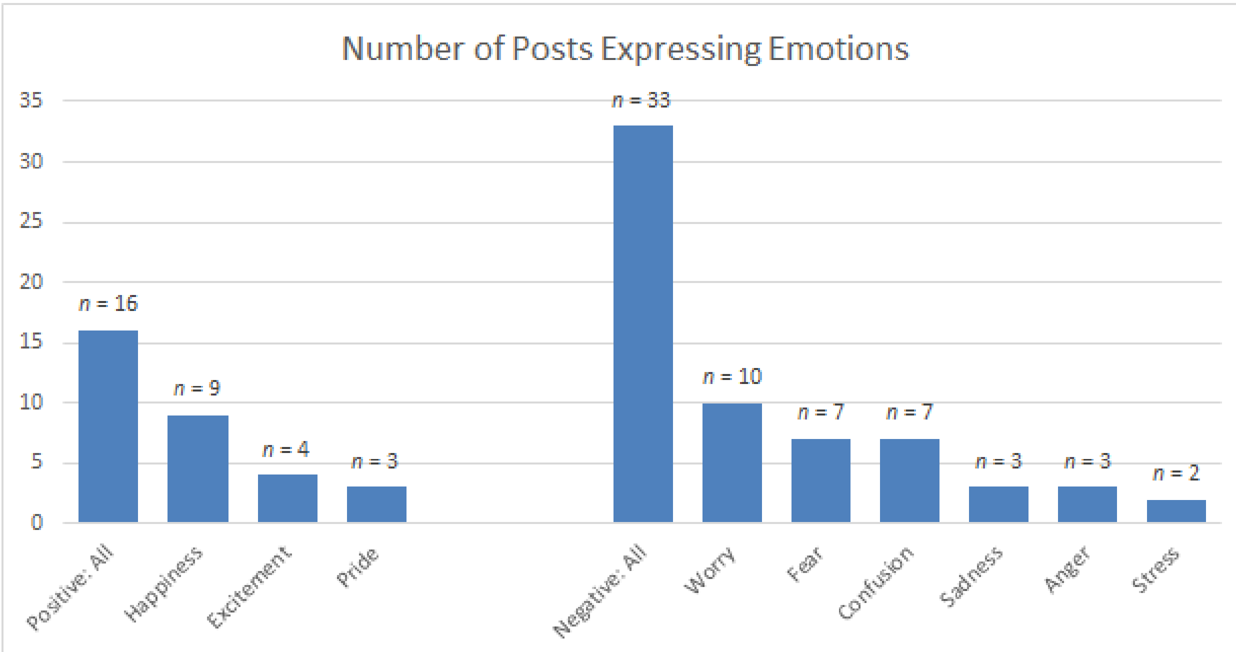


Figure 19. Number of total posts expressing emotions, by type of emotion.

Illustrative Example: Emotional Expression: Negative (A). "Everything I'm doing is helping my blood glucose get down to a better level slowly (and yes, I'm always afraid of messing up again!"

Illustrative Example: Emotional Expression: Positive (B). "I want to take the time to say how thankful I am that this forum exists and how happy it made me to come across it again and see the names of familiar people still managing their diabetes."

It was possible for a post to express more than one emotion, as in the examples above taken from a single post. In this post the user expressed both negative and positive emotions: (A) fear that his or her glucose control may worsen in the future, and (B) happiness at finding the forum again and seeing that familiar posters have remained active on it. This emphasized the point that the major benefits of the forum were not limited to supporting the informational needs of its users; it also addressed the emotional needs that may come with managing a chronic illness. Any decision support system designed to assist in diabetes self-management must be developed with an understanding of the psychosocial aspects of self-management to take both types of support needs into account.

Discussion

In two experiments, we have unearthed promising roots of decision aid design. In one, we learned how persons with a chronic health condition communicate with others with the same condition: what kinds of questions do they have? What understanding do they lack? What kinds of support do they seek and receive? Through this, we may inform the content and interaction of decision support systems. However, even the most accepted decision support will be useless if it does not improve performance and/or learning. Thus, Study 1 tackled the question of automation support - looking for the best combination of automation level and type to result in optimal food choices.

Study 1

One result from Study 1 was that younger adults tended to outperform older adults during all phases of the study. The task was novel and cognitively complex and required the use of working memory and reasoning. These cognitive abilities tend to decline with age (Park & Schwarz, 1999; Salthouse, 2004), the age differences reflected in our task scores followed the pattern predicted by the literature on age-related cognitive change. This age-related performance difference was reflected in participant self-ratings of performance.

Interestingly and contrary to the prediction, task scores for both age groups were significantly higher during the post-test than during the treatment phase. It was predicted that task scores would be highest during the treatment phase, in which participants were aided by their assigned level of decision support, and decrease between the treatment and post-test phases as the decision support was removed. This pattern was not observed in the scores. Task scores were steady between the pre-test and treatment phases, and subsequently increased between the treatment and post-test phases. Comparisons between support groups to examine the effects of different components of information acquisition decision support and the presence of information analysis support on the outcomes of performance, learning, and reliance followed the same pattern. For these comparisons there was a significant effect of phase, such that performance was higher at post-test, but no significant effect of support group or interactions between phase and group. One possible explanation for this effect arises from a limitation of the study design.

Limitations of Study 1. One limitation of the study was the length and spacing of the separate phases of the task. As the task was novel for the participants, we could reasonably expect a practice effect such that scores were lowest at pre-test and increased with each subsequent phase. This helps explains the fact that scores were lowest at pre-test, when participants had the least practice with the task, and higher at post-test, when they had the most practice with the task. If the practice effect was a greater influence on scores than the influence of the presence or absence of decision support, we would indeed expect to see highest performance at post-test. However, this does not fully explain why task scores remained steady between pre-test and treatment. Both the practice effect and the presence of decision support during the treatment phase suggest that scores should be higher during the treatment than during the pre-test. A further explanation may arise from the way the experimental phases were set up.

To give participants more time performing the task under the condition of decision support, participants were shown twice as many questions and given twice as much time during the treatment phase than either the pre-test or post-test phases. To allow comparisons between the phases the treatment scores were divided by two. This transformation, however, assumes that 50% of a participant's score during the longer treatment phase was equivalent to 100% of a participant's score during the shorter pre-test or post-test phases. Even though there was no break or pause between phases, the phases were not truly continuous; each phase was presented to participants on a new webpage. This could have introduced the unwanted effect where performance differed across the span of each individual phase, perhaps in terms of motivation or fatigue, and the increased span length of the treatment phase made it qualitatively different from the other two phases.

Conclusions of Study 1. Even though this study did not reveal significant differences between levels of support or the individual components of support, it did suggest some implications for the design of decision support systems to improve diabetes self-management. First, the observed age-related differences in task scores suggested that older adults were more likely to struggle with carbohydrate counting and meal planning to meet nutritional goals. Although younger adults tended to score more highly, they also tended to report that the task was more tiring or fatiguing than did older adults. Providing decision support during this and other tasks of self-management remains an important goal for both younger and older persons with diabetes.

Future Directions for Study 1. While effective support systems remain a goal, the exact level and form that support should take to best support performance and learning is however less clear, as is the magnitude of the risk of skill degradation (Wiener & Curry, 1980) arising from reliance on an automated support system. Future studies should examine exactly how participants take advantage of decision support when it is present. For example, eye tracking could be used to examine the distribution of visual attention under different conditions of information acquisition support.

Study 2

On the applied side, the analysis of forum posts in a type 2 diabetes forum suggested that an internet forum can fulfill important needs relating to the self-management of diabetes. First, the forum was a source of informational support in the forms of advice, descriptions of others' experiences, and teaching. A decision support system could address these needs by providing advice that is customized to a user, as well as providing teaching on frequently discussed topics like diet and diabetes medication usage. It could facilitate connections between users who could share experiences as well. Second, the forum was also a source of emotional support, and users expressed both positive and negative emotions while discussing diabetes and their management of it. Any decision support system for diabetes self-management should acknowledge the psychosocial aspects of managing a chronic illness like diabetes. The system could detect appropriate moments to deliver emotional support to the user. For example, the system could provide encouragement when the user appears to be discouraged or congratulations when the user celebrates a success. Because emotional support from a system is not expected to be equivalent to emotional support from a person, the system could also connect users with each other to facilitate human-to-human emotional support.

Limitations of Study 2. The results of the study also suggest that very specific topics, like the use of technology in diabetes self-management, may not be best examined through a random sampling of forum posts like we performed in the study. Unless a topic is discussed very frequently, such as dietary issues or medication usage, a random sampling will not lead to a large enough sample to draw sufficient conclusions. Given the time requirements of qualitative coding, if a random sampling approach is desired it might be more appropriate to focus on only coding a small portion of a coding scheme containing only the codes of direct interest. For example, if the targeted topic is the use of technology in diabetes self-management, posts could be first examined for references to technology and then only coded if they contain one. Targeted approaches may also be more successful.

Keyword search via the use of key terms, e.g. “smart phone” or “app,” could more quickly identify posts containing information of interest if the list of keywords is complete and comprehensive.

Future Directions for Study 2. Future studies should also examine the exchange of informational and emotional support in more depth by examining replies in response to a first post. Particular attention should be paid to first posts and replies likely to describe problem processes performed in the self-management of diabetes, whether the process is an individual one or it is performed collaboratively between multiple users. Furthermore, comparisons between the results of this analysis and one examining a forum centered on a short-term health condition could provide important clues about the differences in support needs between those experiencing an acute illness and those whose illness is chronic. Although the quality of advice we observed on the forum was generally good, a formal analysis of information accuracy and advice quality is necessary to understand if internet forums - and consequently, their users - are capable of acting as a reliable, high-quality source of information. If the quality is indeed high, incorporating social information sharing as a feature of a decision support system could be a valuable approach.

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Appendix

Adapted Diabetes Knowledge Questionnaire

You will see some sentences about type 2 diabetes and food. Please choose how much you agree or disagree with each sentence. If you aren't sure, please choose the middle answer of "Not Sure."

	Strongly agree	Agree	Not Sure	Disagree	Strongly Disagree
Eating too much sugar and other sweet foods is the cause of type 2 diabetes.	○	○	○	○	○
For people with type 2 diabetes, an insulin reaction is caused by too much food.	○	○	○	○	○
Medication is more important than diet and exercise to control type 2 diabetes.	○	○	○	○	○
For people with type 2 diabetes, the way they prepare foods is as important as the foods they eat.	○	○	○	○	○
A diet for type 2 diabetes consists mostly of special foods.	○	○	○	○	○