


## ORIGINAL ARTICLE

## Epidemiology/Genetics

# In their own words: Topic analysis of the motivations and strategies of over 6,000 long-term weight-loss maintainers

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## Abstract

**Objective:** This study aimed to identify major themes of a large cohort experiencing long-term weight-loss maintenance who answered open-ended questions about weight-loss triggers, current motivations, strategies, and experiences.

**Methods:** Machine learning and topic modeling were used to analyze responses to six open-ended questions among 6,139 WW International, Inc., (formerly Weight Watchers) members with weight-loss maintenance; inclusion criteria included  $\geq 9.1$ -kg loss with weight-loss maintenance for  $\geq 1$  year.

**Results:** Participants (mean age = 53.6 years; 94.3% White; mean BMI = 27.8 kg/m<sup>2</sup>) had lost 24.5 kg and maintained the loss for 3.4 years. Descriptions of factors triggering weight loss coalesced into five topics: medical status, appearance, mobility, social prompts, and change needed. Factors currently motivating weight-loss maintenance yielded two topics: looking back at experiences at higher weight and health/appearance concerns. Advice for others to succeed in weight-loss maintenance coalesced on two recommendations: perseverance in the face of setbacks and consistency in tracking. Rewards for weight management included improved confidence, pain, mobility, fitness, body image, medical status, and affect. Two thematic negative consequences were clothing costs and sagging skin.

**Conclusions:** Future weight-maintenance research should include more diverse populations and investigate weight-loss maintenance as a journey with highs and lows, perseverance in the face of setbacks, sustained tracking, and making changes in medical status more salient during the weight-maintenance journey.

## INTRODUCTION

Modest weight loss can reduce long-term risk of cardiometabolic disease, but these improvements are attenuated with weight regain, which affects most individuals. Biological, behavioral,

psychological, sociocultural, and environmental pressures promote weight regain. Nevertheless, about 20% of individuals who have lost weight in the US population are able to keep it off long term and experience ongoing improvements in quality of life and health status (1-3).

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Research of weight-loss maintainers from the WW International, Inc., (formerly Weight Watchers) Success Registry (WWSR), the National Weight Control Registry, and the German and Portuguese Weight Control Registries have characterized factors that allow some people to succeed at long-term weight-loss maintenance (4-7). Among the modifiable factors are eating a lower-calorie diet, engaging in high levels of physical activity, frequent self-monitoring, problem solving, setting daily intake goals, limiting sitting time, and keeping low-calorie foods accessible (6,8-10). Psychological strategies include cognitive restraint (11) and frequent practice of healthy coping skills such as “thinking about past successes” and “remaining positive in the face of weight regain” (9).

These large-scale registry studies have included validated questionnaires, and findings have led to novel advancements in intervention research (12-14). However, reliance on closed-ended, researcher-determined questions may fail to capture the rich array of thoughts, feelings, values, behaviors, and beliefs that surround the experience of long-term weight-loss maintenance. Qualitative studies with focus groups and in-depth interviews have uncovered new perspectives. For example, a 2015 meta-synthesis of qualitative research of weight-loss maintainers characterized “sources of tension” (e.g., old habits and impulses, pleasure, discomfort in new body image) that may disrupt weight-maintenance success and identified several strategies to manage this tension (e.g., self-regulation skills) or reduce it (e.g., developing automaticity, changing beliefs and self-concept) (15). However, this meta-synthesis and other qualitative research in the area have relied on small sample sizes and employed different methodologies, analysis techniques, and definitions of successful weight-loss maintenance. Large-scale registry studies of weight-loss maintainers have generally shied away from open-ended questions owing, in part, to the labor-intensity of analyzing textual responses from thousands of participants. However, technological advances now allow for analysis of textual responses from large data sets.

The purpose of this study was to identify major themes in the responses of a large cohort of long-term weight-loss maintainers in a commercial weight-management program who answered open-ended questions about their motivations, strategies, and experiences. Machine learning and topic modeling were used to analyze responses of more than 6,000 long-term weight-loss maintainers.

## METHODS

This is a mixed method, cross-sectional investigation of weight-loss maintainers in the WWSR. The WWSR is an observational study of individuals who lost weight in WW and were successful at long-term ( $\geq 1$  year) maintenance of substantial ( $\geq 9.1$  kg) weight loss. WW is a widely available behavioral weight-management and wellness program that has been studied extensively (16-19). Prospective weight-loss maintainers were recruited through an email sent by WW to members who had reported a loss in WW of  $\geq 9.1$  kg for at least 1 year. Interested individuals were referred to the study website

### Study Importance

#### What is already known?

- ▶ Registries of weight-loss maintainers have analyzed data from closed-ended, researcher-determined questions to describe the factors that allow some people to succeed at weight-loss maintenance.
- ▶ Weight-loss maintainers have reported eating a low-calorie diet, engaging in high levels of physical activity, frequent self-monitoring, problem solving, setting daily intake goals, limiting sitting time, and keeping low-calorie foods accessible.

#### What does this study add?

- ▶ This is the first study, to our knowledge, to use machine learning and topic modeling to analyze the written responses of more than 6,000 weight-loss maintainers who described their motivations, strategies, struggles, and successes with long-term weight management.
- ▶ Weight-loss maintainers in WW International, Inc., (formerly Weight Watchers) advised perseverance in the face of setbacks, consistency in food tracking, and looking back at experiences of life at higher weight and described improved health and appearance as motivating factors in their weight-loss journeys.

#### How might these results change the direction of research?

- ▶ Findings may lead researchers to study interventions that promote perseverance in the face of setbacks, encourage tracking of intake, and make changes in medical status more salient during the weight-loss journey.

hosted by California Polytechnic State University (Cal Poly), San Luis Obispo, for online screening, consent, and enrollment. Eligibility was based on self-reported weight, height, weight change, and duration of weight loss. To be eligible for enrollment, individuals self-reported age  $\geq 18$  years and maintenance of  $\geq 9.1$  kg loss from WW entry for  $\geq 1$  year. Study procedures were approved by the Cal Poly Institutional Review Board, and all participants provided informed consent electronically via Research Electronic Data Capture (REDCap; Vanderbilt University, Nashville, Tennessee).

### Measures and open-ended questions

All measures were administered online via REDCap immediately after consent. Closed-ended questions asked participants standard questions on demographics (age, education level, income, marital

status, race/ethnicity, and gender) and details about weight history (weight-loss duration, age of onset of overweight, and maximum lifetime weight), as well as current weight and height (7,20).

A series of open-ended questions were designed to capture the factors that prompted their successful weight loss, the factors that continued to motivate them and promote success, and the consequences of weight-loss maintenance. All questions are listed in Table 1. There were no character limits set on responses. Participants were not required to respond to the open-ended questions.

## Statistical analysis

Descriptive statistics were used to describe participant characteristics, and independent *t* tests and  $\chi^2$  tests were used to compare the characteristics of WWSR participants who responded versus participants who did not respond to the open-ended questions.

A machine-learning, natural-language-processing approach with Latent Dirichlet Allocation (LDA) was used to analyze the open-ended questions. LDA is an unsupervised (i.e., data-determined) topic-modeling method (21,22). The method is similar to a cluster analysis. LDA assumes that the collection of responses to each question contain probability distributions of latent topics, and topics contain probability distributions of words. Word frequency and co-occurrence of words are used to cluster words and phrase patterns together and to form underlying topics. LDA assigns probabilities (i.e., word weights) of each word appearing in each underlying topic.

Prior to LDA analysis in the current study, text was segmented into words (i.e., tokenization), and words with little informational value were removed (i.e., of, which, the, such). Also, an auto-stemming process was implemented to arrive at a word root. For inclusion in the analysis, no minimum word length was set. The topic-modeling implementation parameter (*eta*) was set to 0.01 to minimize overlap between topics for each question, and three models were trained for each question: a two-topic model, a three-topic model, and a five-topic model. From these quantitatively extracted topic models, the research team determined the optimal number and names of topics following an iterative process (21) based on the following: 1) topic coherence (i.e., how well the words in each topic related conceptually); 2) the top 20 most frequent words within each topic, devaluing words with low frequencies (<50 incidences

in five-topic models and <100 incidences in two-topic models) and those that were in the open-ended question itself (e.g., “weight,” “motivate”); 3) consideration of word weights (i.e., the probability the corresponding word belonged to that topic) (22); and 4) a review of a random selection of  $\geq 100$  participant responses containing the words associated with each topic. For presentation in the paper, a subset of the team (SP, JR, and SMN) selected representative quotes for each topic that were narrowed down and lightly edited for grammatical errors (Tables 3-7) (23). R (R Foundation, Vienna, Austria) and SPSS Statistics version 25.0.0 (IBM Corp., Armonk, New York) were used in analyses of descriptive statistics,  $\chi^2$ , and *t* tests. Python (Python Software Foundation, Wilmington Delaware) was used for the unsupervised, machine-learning analysis.

## RESULTS

Of the 7,419 enrolled, 82.7% ( $n = 6,139$ ) responded to at least one open-ended question and thus were included in this study. Participant characteristics are displayed in Table 2. In examining the characteristics of participants who responded versus those who did not respond to the open-ended questions, they differed on magnitude of initial weight loss since starting WW (mean [SD], 24.5 [12.5] kg vs. 23.5 [11.9] kg,  $p = 0.007$ ), current WW membership (88.3% vs. 82.0%,  $p = 0.001$ ), being married (74.1% vs. 67.9%,  $p = 0.005$ ), and being White (94.3% vs. 33.2%,  $p = 0.001$ ), but they did not significantly differ on age, current BMI, gender, duration of weight maintenance, income, education, employment, or other demographic variables (data not shown). Weight-loss maintainers had lost, on average, 24.3 kg from their WW starting weight and maintained weight loss for an average of 3.4 years. They were, on average, 53.6 (12.6) years old; 91.9% identified as female; 94.3% identified as White; 71.2% were married; 65.7% were employed; 64.5% had an annual income more than \$75,000; and 88.2% had a college education or more.

### Sources of motivation

When asked about the factors that prompted successful weight loss, responses clustered into five topics (Table 3): topic 1) “Medical

**TABLE 1** Open-ended questions and number of participants who responded to each question among 6,139<sup>a</sup> weight-loss maintainers

Weight-loss triggers	• What prompted you to start your weight-loss attempt? Please describe. ( $n = 6,092$ ; 82.1%)
Motivation	• What currently motivates you to manage your weight? ( $n = 5,710$ ; 77.0%)
Advice	• What is one piece of advice that you would give to help someone succeed at long-term weight loss? ( $n = 5,524$ ; 74.5%)
Changes	• What is the single most important thing in your life that has changed as a result of weight loss? ( $n = 5,384$ ; 72.6%) • Please describe any negative consequences of successful weight loss. ( $n = 4,761$ ; 64.2%)
Other	• If applicable, please use this section to describe any other factors affecting your weight history that have not been addressed. ( $n = 1,010$ ; 13.6%)

<sup>a</sup>Of the 7,419 enrolled in the WW Success Registry, 82.7% ( $n = 6,139$ ) responded to at least one open-ended question, 74.6% responded to at least three, 64.2% responded to at least five, and 12.9% responded to all six of the open-ended questions.

**TABLE 2** Characteristics of WW weight-loss maintainers

Age at WW enrollment, mean (SD), y	49.4 (12.8)
Age at study enrollment, mean (SD), y	53.6 (12.6)
Female (%)	91.9
Currently in WW (%)	87.9%
Lifetime maximum weight, mean (SD), kg	105.5 (23.1)
Weight at start of WW, mean (SD), kg	101.3 (21.5)
Lowest weight, mean (SD), kg	71.1 (15.5)
Current weight, mean (SD), kg	77.0 (17.0)
Weight loss since WW start, mean (SD), kg	24.5 (12.5)
Duration of $\geq 9.1$ -kg loss from WW start weight, mean (SD), y	3.40 (3.79)
Weight lost from maximum weight, mean (SD), kg	28.5 (15.0)
Current BMI, mean (SD), kg/m <sup>2</sup>	27.8 (5.56)
<b>BMI categories</b>	
Obesity (%)	23.7
Overweight (%)	43.6
Normal weight (%)	32.6
Underweight (%)	0.0
<b>Income (total in family per year)</b>	
<\$25,000 (%)	4.9
\$25,000-75,000 (%)	30.6
$\geq$ \$75,000 (%)	64.5
<b>Race/ethnicity</b>	
White (%)	94.3
Black (%)	2.8
Hispanic (%)	4.0
Employed (%)	65.7
College education or more (%)	88.2
Married (%)	71.2

Triggers,” reflecting a high number of words related to medical status (health, live, diabetes, heart, risk, insulin); topic 2) “Appearance,” containing a high number of words related to concerns over looks (clothing, fit, look, feel); topic 3) “Mobility,” reflecting concerns related to bodily movement (walk, stairs, knee); topic 4) “Social Prompts,” describing the role others played prompting their weight loss (WW, friend, doctor, husband, daughter, child); and topic 5) “Change Needed,” reflecting feelings of hitting a maximum threshold of tiredness (tired); this topic also included terms that were more scattered among different subjects (e.g., picture, fat, age, change).

Participants were also asked to describe what currently motivated them, and responses clustered around two main topics (Table 4): topic 1) “Looking Back,” centering around a desire to avoid negative experiences of the past given all the time and work that went into achieving their goal (back, goal, work, year, time, hard); and topic 2): “Health and Appearance,” which focused on the desire to maintain health and feel good in clothes (health, clothing, fit, feel, enjoy).

## Strategies for success

Participants were asked about the one piece of advice that they would give to help someone else succeed at long-term weight loss. Responses clustered around two main topics, and they are shown in Table 5. “Perseverance” reflected an approach that encouraged never giving up, taking it day by day, using meetings to reset after difficult weeks, and embracing the journey and long-term goal (give, day, time, work, meet, goal, stick, small, journey). Topic 2 was labeled “Tracking and Lifestyle,” as weight-loss maintainers described tracking food intake as an essential skill within a healthy lifestyle (track, eat, change, lifestyle, healthy, slow, habit).

## Consequences of weight-loss maintenance

Participants were asked about the most important thing that has changed as a result of weight loss. Responses are in Table 6, and they clustered around five topics: topic 1) “Confidence,” reflecting improved self-confidence, esteem, and happiness (confidence, health, self, energy, happy, esteem); topic 2) “Reduced Pain,” including descriptions of less pain doing exercise and activities of daily life (pain, life, exercise, walk, back, time); topic 3) “Fitness and Body Image,” which described an active lifestyle and fitting into clothes (active, clothing, level, fit, physical, ability, energy, move); topic 4) “Medical Status,” which included feeling healthier and improvements in blood pressure, cholesterol, and diabetes and a longer life; and topic 5) “Positive Affect,” which included terms about feeling at ease and more comfortable in mind and body (feel, comfort, body, appear, life) but also included other words that made this topic less coherent (eat, control).

When asked about negative consequences of successful weight loss, responses centered on two topics (Table 7). Topic 1 was “Clothing and Criticism,” reflecting words about the money spent buying new clothes and unexpected criticism from other people; this cluster also included other, more scattered themes (clothing, people, eat, buy, money, friend, time). The second topic was labeled “Skin and Effort Required,” reflecting words about excess skin and the hard work involved in weight-loss maintenance (skin, back, hard, body, sagging).

Participants were also given the opportunity to describe other factors affecting their weight history. Only a minority of the sample ( $n = 1,010$ ; 13.6%) responded. Words were mostly scattered, but a commonality was the word WW (or the former program name, Weight Watchers), describing comments on the WW program itself (e.g., “One thing I wasn’t able to express is how important my personal support has been - maybe not always from my spouse or family members, but from other WW members and friends”). Another participant described, “The support found in meetings and relationships with other WW members has been instrumental in keeping me accountable to maintaining the weight loss.” A second and related word was “time,” describing the number of times participants had “been down this road” and joined and rejoined WW (e.g., “I had

**TABLE 3** Topics and representative quotes from weight-loss maintainers ( $n = 6,092$ ) who responded to the following question: "What prompted you to start your weight-loss attempt?"

Topics (% responses) <sup>a</sup> Words (frequency/ weighted probabilities) <sup>b</sup>	Representative quotes
1. <i>Medical</i> (15.3%) Health (2,111/0.071) Live (93/0.060) Diabetes (194/0.054) Heart (115/0.036)	<ul style="list-style-type: none"> <li>• "<b>Health</b> issues: Diagnosed with breast cancer earlier same year; arthritis (prior knee replacement); newly diagnosed asthma; rising blood pressure; osteopenia. Don't want to end up in wheelchair like my mother and follow family history of <b>heart</b> attacks/strokes."</li> <li>• "My doctor told me at age 32 that I wasn't going to make it to 35. I was on a lot of medication for high blood pressure, <b>prediabetes</b>, etc. I wanted to lose weight to get off meds and <b>live</b> a fuller life."</li> <li>• "My family also has a history of <b>heart</b> problems, yet we live into our 90s. If I had to live that long, I wanted to be <b>healthy</b>."</li> <li>• "I was <b>unhealthy</b>. Knee pain, foot pain, high blood pressure, high cholesterol. Unable to be active."</li> </ul>
2. <i>Appearance</i> (25.2%) Clothes (599/0.070) Fit (373/0.050) Look (483/0.039) Feel (346/0.032)	<ul style="list-style-type: none"> <li>• "Embarrassed that the only <b>clothes</b> that <b>fit</b> were pajamas from my closet. Uncomfortable with social situations that were not a problem in the past."</li> <li>• "I was uncomfortable in my body and unhappy with how I <b>looked</b>. I was disappointed in myself and hated how I <b>looked</b> in pictures from a friend's wedding where my dress <b>felt</b> tight."</li> <li>• "The biggest slap in the face was when I went to go <b>clothes</b> shopping and realized I had "sized out" of my favorite store. This meant I would have to go to less fashionable stores to get something that <b>fit</b>."</li> <li>• "Wanted to <b>feel</b> better about myself. I wasn't happy with how I <b>looked</b> or <b>felt</b>. I wanted to be happy, <b>look</b> good, and not be or <b>feel</b> limited in what I wore or what I did."</li> </ul>
3. <i>Mobility</i> (16.4%) Walk (80/0.44) Stairs (62/0.007) Knee (128/0.006)	<ul style="list-style-type: none"> <li>• "I was tired of feeling sick and tired. I couldn't climb <b>stairs</b> without being extremely out of breath. I was embarrassed to <b>walk</b> up <b>stairs</b> with other people because I couldn't carry on a conversation with them. I was also embarrassed when I would have to get in a booth at a restaurant and couldn't fit."</li> <li>• "I couldn't <b>walk</b> to the mailbox without losing my breath and my family was worried about my health."</li> <li>• "<b>Knee</b> pain, lack of mobility, and no energy. Could not bend over to tie my shoes, could not climb <b>stairs</b>."</li> <li>• "I was having difficulty <b>walking</b>, experiencing severe pain in my feet, ankles, and <b>knees</b>. While on vacation in NYC, my feet hurt so badly, that I had to buy tennis shoes with orthotics, because the <b>walking</b> shoes I had packed were no longer comfortable. I couldn't do some of the activities we had planned, because I was in so much pain. Plus, I had started using a cane for support. I knew I had to do something!"</li> </ul>
4. <i>Social prompts</i> (18.0%) WW (389/0.055) Friend (186/0.027) Doctor (193/0.025) Husband (140/0.016) Daughter (138/0.016) Child (228/0.015)	<ul style="list-style-type: none"> <li>• "I had a <b>doctor's</b> appointment in which my <b>doctor</b> told me that she could no longer weigh me on the scale at the office and directed me to a gym that had a scale. I was embarrassed but went to that gym and the scale said I was 360 lb. Shortly after that, a man pulled on my shirt sleeve and told me that I was the biggest woman he had ever seen. I was shocked, but went home, looked in the mirror, and realized I <b>WAS</b> the biggest woman. I was the biggest woman at church, the biggest woman at the store, the biggest woman at work, etc. I didn't want to be that person anymore, so I joined <b>WW</b>."</li> <li>• "Two <b>friends</b> who had achieved success on <b>WW</b> encouraged me to come to meetings with them. At the time, I was overwhelmed by the amount of weight I had to lose. I felt disgusted with how I looked and felt."</li> <li>• "I had a <b>friend</b> who was doing <b>WW</b> and I called her and told her I needed to talk to her. I went over that day and cried and told her I needed to change something. She then invited me to come to <b>WW</b> with her the next Tuesday and I've been going ever since."</li> <li>• "I wanted to set an example for my <b>granddaughters</b> and also be able to keep up with/be a healthy caregiver for my <b>husband</b>."</li> <li>• "I wanted to lose weight before starting a family. Wanted to lose weight to be healthy for them and a good role model for my <b>children</b> by modeling a healthy lifestyle."</li> </ul>
5. <i>Change needed</i> (26.1%) Tired (662/0.070) Picture (243/0.021) Fat (230/0.014) Change (147/0.016) Age (124/0.033)	<ul style="list-style-type: none"> <li>• "I was <b>tired</b> of feeling sick and <b>tired</b> all the time. Too many aches and unable to bend or enjoy life to the fullest."</li> <li>• "<b>Tired</b> of hurting and not being able to do stuff that I should be able to do at my <b>age</b>."</li> <li>• "I was <b>tired</b> of feeling bad and I looked awful in <b>pictures</b>. I had '<b>fat</b> girl' clothes."</li> <li>• "I was <b>tired</b> of feeling <b>fat</b> and uncomfortable. Embarrassed of myself in <b>pictures</b> from a family wedding."</li> <li>• "I felt terrible about myself. I hit bottom emotionally and knew I had to make a <b>change</b>."</li> </ul>

<sup>a</sup>% responses indicate the proportion of the responses reflected in the topic.

<sup>b</sup>Weighted probabilities indicate the extent to which a word is uniquely associated with a topic; although words within each topic were not analyzed jointly, they clustered within responses and shared a unique association with the same topic. Results are from analysis with stemming. This is not an exhaustive list of the 20 words extracted for each topic. Shown are the most frequent (>50) and highly weighted words in each topic.



**TABLE 4** Topics and representative quotes from weight-loss maintainers ( $n = 5,710$ ) who responded to the following question: "What currently motivates you to manage your weight?"

Topics (% responses) <sup>a</sup> Words [frequency/ weighted probabilities] <sup>b</sup>	Representative quotes
<b>1. Looking back (41.5%)</b> Back (593/0.054) Goal (219/0.024) Gain (465/0.021) Work (228/0.019) Year (153/0.015) Time (132/0.015) Hard (119/0.011)	<ul style="list-style-type: none"> <li>• "What motivates me is the thought of <b>gaining</b> all that weight <b>back</b> and the negative impact it would have on me. I don't know if I would have the energy to start over. It is better for me to stay within a couple pounds of <b>goal</b> weight and take it off when necessary."</li> <li>• "Fear of going <b>back</b> to the way I was and throwing all these <b>years</b> down the tubes. It took me too many <b>years</b> to reach <b>goal</b> and it was a <b>hard</b> road."</li> <li>• "Remembering how it felt all these <b>years</b> at a heavier weight."</li> <li>• "I don't want to go <b>back</b> to hurting and feeling sick all the <b>time</b>."</li> <li>• "It was a lot of <b>work</b> to get to my current weight. and if I <b>gain</b> it <b>back</b>, I'll have to start all over again. It's <b>harder</b> being overweight than it is to <b>work</b> at a healthy lifestyle."</li> <li>• "Knowing that starting a weight-loss journey is the <b>hardest</b> part. I do not want to retreat <b>back</b> to when it was difficult."</li> </ul>
<b>2. Health and appearance (58.5%)</b> Health (1,953/0.075) Clothes (1,068/0.067) Fit (489/0.039) Feel (483/0.034) Enjoy (151/0.011)	<ul style="list-style-type: none"> <li>• "How I <b>feel</b> physically and how I look physically. I love being able to do whatever activities I choose to and my boundless energy. I <b>feel</b> physically beautiful again and I love buying <b>clothes</b>! Looking at my before pictures keeps me humble, recalling my "non-scale-victories" keeps me motivated daily."</li> <li>• "<b>Health</b>, <b>feeling</b> comfortable in my own skin, ability to walk up stairs, tie my shoes, wear smaller <b>clothes</b>, <b>fit</b> into airplane seats and seatbelts, wear a swimsuit in public..."</li> <li>• "Primarily maintenance of better <b>health</b> (excellent A1C, blood pressure controlled). Looking better and being able to shop for normal-sized <b>clothes</b>. Being able to hike, bike, and walk without fear of failure."</li> <li>• "It is great going into a store and having <b>clothes</b> that not only <b>fit</b> but look good. Also, I look so much better in pictures."</li> <li>• "I <b>enjoy</b> being <b>healthy</b>, free from taking medication to lower blood pressure or cholesterol, and I no longer need a CPAP machine to sleep. Plus I <b>enjoy</b> wearing normal sized <b>clothes</b>."</li> </ul>

Abbreviation: CPAP, continuous positive airway pressure.

<sup>a</sup>% responses indicate the proportion of the responses reflected in the topic.

<sup>b</sup>Weighted probabilities indicate the extent to which a word is uniquely associated with a topic; although words within each topic were not analyzed jointly, they clustered in responses and shared a unique association with the same topic. Results are from analysis with stemming. This is not an exhaustive list of the 20 words extracted for each topic. Shown are the most frequent (>100) and highly weighted words in each topic.

joined WW so many times, but this time I was determined to stick with it.").

## DISCUSSION

This is the first study, to our knowledge, to use topic modeling to understand experiences of more than 6,000 weight-loss maintainers in WW who wrote about their motivations, strategies, struggles, and successes with long-term weight control. Weight-loss maintainers described obesity-related memories, health, and appearance concerns as motivating both the initiation and sustainment of long-term weight loss. Perseverance in the face of setbacks and tracking food intake over time were recommended to others seeking similar weight-loss success. Profound rewards for their weight-management efforts were described, including major improvements in confidence, pain, mobility, body image, and mental and physical health. Some negative consequences were clothing costs, sagging skin, and unexpected criticism from others. In addition to common experiences, weight-loss maintainers described unique pathways in the weight-loss maintenance process.

Appearance concern was identified as a major motivator of both weight loss and maintenance. Participants described initiating

successful weight-loss efforts out of intense feelings of "shame" and "disgust" after looking at themselves in the mirror or in photographs; many described "not knowing who they'd become" and feeling as if they were "ruining" other people's pictures of events. Participants also described profound embarrassment while shopping for clothes and being unable to fit into clothes, and the ability to fit into clothes was reported by many as the most important thing that changed as a result of weight loss. These findings suggest that appearance concerns may shape not only weight loss but weight maintenance. The persistence of appearance-based concerns may reflect a distressing sociocultural environment that ties appearance with self-concept, stigmatizes and discriminates against people with obesity, and promotes an arbitrary definition of beauty based on a Western thin ideal (24,25). Today, 70% of the US population is living with overweight or obesity; however, many weight-loss maintainers described initiating weight-loss efforts out of a pressing desire to "become normal." Systems and social-ecological-based approaches to weight management may hold promise for combatting the prevailing sociocultural climate of weight-based stigma and discrimination and resulting self-esteem (26,27).

Medical health was identified as another powerful theme motivating successful weight loss and maintenance. Prior research on

**TABLE 5** Topics and representative quotes from weight-loss maintainers ( $n = 5,524$ ) who responded to the following question: “What is one piece of advice that you would give to help someone succeed at long-term weight loss?”

Topics (% responses) <sup>a</sup> Words (frequency/ weighted probabilities) <sup>b</sup>	Representative quotes
<b>Perseverance (54.5%)</b> Give (855/0.048) Day (680/0.045) Time (681/0.043) Work (430/0.029) Meet (410/0.023) Goal (306/0.021) Stick (336/0.018) Small (209/0.011) Journey (310/0.012)	<ul style="list-style-type: none"> <li>• “Simply put one foot in front of the other and start and never stop. Just keep going. Know that if you persevere, you will get there. There will be peaks and valleys, plateaus, gains, holidays, bad <b>times</b> but just get up and do what <b>works</b> 80 to 90% of the <b>time</b> and you will get there. Do Not Stop. Never accept a <b>small</b> failure as a total defeat. If you truly want to accomplish and maintain weight loss, you can do it.”</li> <li>• “Don't <b>EVER</b> <b>give</b> up. You can have a bad <b>day</b>, a bad week, month, or even year, but you can always start where you are and change your own ending. I've had weeks where I've done everything right and still the scale didn't reflect that hard <b>work</b>. But my body did. The way I felt did. You just have to keep going and keep <b>working</b> hard and it will pay off eventually.”</li> <li>• “Success is made up of lots of little decisions made every <b>day</b>. Show up for yourself and don't allow yourself to start quitting in <b>small</b> ways because they lead to quitting everything, and you are worth the commitment and the effort.”</li> <li>• “Long-term weight loss is a <b>journey</b> with highs and lows. You may gain weight during the <b>journey</b> but keep <b>working</b> the program and ask for help when [needed]. There is no shame in failing to <b>meet</b> your <b>goal</b>. We only truly fail, if we stop trying.”</li> <li>• “You have to measure your success based on your long-term <b>goal</b>. You will have <b>times</b> where you are successful and <b>times</b> where you are not”</li> <li>• “<b>Stick</b> with the program. Track and attend <b>meetings</b>. Accountability works.”</li> <li>• “Go ahead and accept that this will be a <b>lifetime</b> of effort and attention. You wouldn't expect to do laundry one <b>time</b> and be done. If you want to lose weight and maintain it, you have to keep doing the <b>work</b>. It's still better than being in pain and unhappy all of the <b>time</b>.”</li> </ul>
<b>Tracking and lifestyle (45.5%)</b> Track (748/0.057) Eat (417/0.050) Change (420/0.035) Lifestyle (375/0.030) Healthy (227/0.017) Slow (191/0.014) Habit (149/0.014)	<ul style="list-style-type: none"> <li>• “You have to get up every day and make a choice to <b>track</b> and <b>eat</b> right. It is going to be difficult, and there will be days that you will fall, but you can get back up and keep moving forward. This is a lifestyle <b>change</b>, not a diet.”</li> <li>• “Tracking, tracking, <b>tracking</b>. I think it was one of the most important parts of my weight-loss journey to use the application and <b>track</b> everything that I consume.”</li> <li>• “<b>Track</b> what you <b>eat</b>, try not to judge yourself, just pay attention.”</li> <li>• “<b>Tracking</b> was instrumental in helping me lose weight, 2+ years later I still <b>track</b> almost every day.”</li> <li>• “Maintain the <b>habits</b> that got you to goal, especially being aware of what you <b>eat</b>.”</li> <li>• “<b>Slow</b> and steady. Think of this journey not as a diet but <b>lifestyle change</b>.”</li> <li>• “Don't worry about the small missteps. It is a <b>healthy lifestyle</b> that will <b>change</b> your life in every way.”</li> <li>• “Don't think of going on a diet. Think of <b>changing</b> your <b>eating habits</b> as part of creating a <b>healthy lifestyle</b>. Also, it's okay to <b>eat</b> the foods you really like, even if they're high calorie, once in a while. It might <b>slow</b> your progress a bit, but you won't resent having to deny yourself a treat now and then.”</li> </ul>

<sup>a</sup>% responses indicate proportion of the responses reflected in the topic.

<sup>b</sup>Weighted probabilities indicate the extent to which a word is uniquely associated with a topic; although words within each topic were not analyzed jointly, they clustered in responses and shared a unique association with the same topic. Results are from analysis with stemming. This is not an exhaustive list of the 20 words extracted for each topic. Shown are the most frequent (>100) and highly weighted words in each topic.

the role of medical factors in motivating weight management has been mixed (28,29). Among long-term weight-loss maintainers in the National Weight Control Registry, “medical triggers,” such as being told by a physician to lose weight or receiving a medical diagnosis, resulted in greater initial weight losses and better maintenance of weight loss over time than nonmedical triggers for weight loss or no trigger at all (28). By contrast, other studies have suggested that medical triggers may lead to less weight loss (29). One clinical trial (30) compared treatments that emphasized medical/health versus appearance concerns and found that treatments that emphasized appearance resulted in more (~3 kg) 6-month weight loss and better maintenance at 12 and 18 months (30). It is possible that appearance concerns are more salient motivators for younger individuals and that medical factors become more salient over time as the health threats imposed by obesity mount and medical care for obesity-related comorbidities becomes needed (31).

A powerful piece of advice that weight-loss maintainers had for others was clear: persevere in the face of inevitable setbacks. Weight-loss maintainers depicted their successful weight loss as “a long marathon with individual victories and setbacks” requiring “great perseverance.” When faced with inevitable setbacks, weight-loss maintainers recommended restarting anew the next day or as soon as possible. Outside of the weight-control literature, research has suggested that perseverance can be promoted by modifying perceptions of effort (32). In educational settings, “grit” has been considered teachable and defined as “perseverance to accomplish long-term or higher-order goals in the face of challenges and setbacks” (33). Future research in weight management should prioritize the inclusion of validated measures of perseverance and explore novel approaches to promote it during weight maintenance.

The other major theme that emerged was the importance of tracking, which aligns squarely with prior research (34).

**TABLE 6** Topics and representative quotes from weight-loss maintainers ( $n = 5,384$ ) who responded to the following question: "What is the single most important thing in your life that has changed as a result of weight loss?"

Topics (% responses) <sup>a</sup> Words (frequency/ weighted probabilities) <sup>b</sup>	Representative quotes
<b>Confidence (19.4%)</b> Confidence (939/0.236) Health (839/0.182) Self (680/0.140) Energy (335/0.051) Happy (181/0.029) Esteem (108/0.029)	<ul style="list-style-type: none"> <li>• "My attitude towards taking on new challenges. I now have <b>confidence</b> that I can achieve things I set my mind to, like losing weight or pursuing an academic or professional goal."</li> <li>• "My <b>confidence</b> in myself. I learned that when I put my mind to it, I can accomplish anything".</li> <li>• "<b>Self-confidence</b>. As a fellow meeting member said, a friend told her 'you look taller.' That's how I feel."</li> <li>• "My attitude has completely changed. What I mean is I am not trying to better for anyone other than myself. For the first time in 10 years I am <b>happy</b> with who I am and where I am in life."</li> <li>• "My <b>health</b> - physical and emotional. Less aches and pains, more <b>energy</b>, more positivity. I feel proud of myself for teaching my kids good habits."</li> <li>• "My <b>energy</b>. I used to be so tired after lunch every day - that 2:30 feeling. Sometimes I would literally lay down in a conference room. I don't know if it is my weight loss or indirectly my <b>healthier</b> lunches, but I have steady <b>energy</b> through the day, and I take some breaks to walk if I'm feeling blah. But nothing like I used to feel."</li> </ul>
<b>Reduced pain (23.0%)</b> Pain (115/0.051) Life (200/0.033) Exercise (66/0.031) Walk (113/0.031) Back (64/0.027) Time (80/0.023)	<ul style="list-style-type: none"> <li>• "I would have to say the physical <b>pain</b> I used to feel on a daily basis... I had so much <b>pain</b> in my <b>back</b> and my knees that it was hard to get up out of bed and now that's not even something that is much of a consideration anymore after having lost so much weight."</li> <li>• "Less body <b>pain</b> and everyday aches. I can be active without hurting"</li> <li>• "Ability to go up and down stairs - physical fitness and less <b>pain</b> in knees."</li> <li>• "Improvement in hip health, less <b>pain</b> when walking."</li> <li>• "<b>Exercising without pain</b>."</li> <li>• "Losing the fear that defined me almost all my <b>life</b>. The fear of going to a restaurant and not knowing if I will fit in the seat. The fear of flying and knowing I will have to ask for the "elephant belt". The fear of not finding a parking space close to the shop where I wanted to go. The fear of <b>walking</b> or running too far because I may not make it <b>back</b>."</li> </ul>
<b>Fitness and body image (17.4%)</b> Active (122/0.072) Clothing (184/0.068) Level (194/0.067) Fit (184/0.063) Physical (250/0.053) Ability (126/0.042) Energy (335/0.042) Move (64/0.022)	<ul style="list-style-type: none"> <li>• "The single most important thing that has changed is how I FEEL <b>physically</b>. I have more <b>energy</b> to play with my kids. I join them in entering local 5K races. We hike, swim, play ball and tag, etc. These are things I could not do easily when I was overweight and so I avoided them. I no longer avoid these <b>activities</b>. In fact, I enjoy them."</li> <li>• "I no longer have anxiety about shopping for <b>clothing</b>. It's been a struggle for as long as I can remember to find the courage to go into a store to try on <b>clothes</b>. I hated wearing the things in my closet, but I hated shopping for <b>clothes</b> even more. It's such a relief to be able to find <b>clothing</b> that I know will <b>fit</b>."</li> <li>• "I now enjoy certain types of <b>clothing</b> that I'd never wear before."</li> <li>• "I truly feel good and happy when I look at myself in the mirror, in pictures, etc. I feel good in my <b>clothing</b>. I feel confident in my <b>clothing</b> and that is the best thing ever."</li> <li>• "I see myself as someone who can be more <b>active</b> and can join in the mainstream <b>level</b> of <b>activities</b> that most people can do."</li> <li>• "My <b>ability</b> to enjoy <b>moving</b> my body whether it is grocery shopping or walking on the beach."</li> </ul>
<b>Medical status (21.7%)</b> Blood (149/0.077) Healthier (122/0.068) Medications (149/0.064) Cholesterol (53/0.026) Longer (128/0.032) Diabetes (64/0.022)	<ul style="list-style-type: none"> <li>• "Off heart <b>medication</b>. Almost off all <b>diabetes medication</b>. My <b>health</b> is so much better."</li> <li>• "My <b>health</b> has improved. I know this because I can exercise for <b>longer</b> periods of time, my <b>blood</b> pressure has dropped, and my <b>blood</b> sugar has dropped."</li> <li>• "Personal <b>health</b> improvement. I'm no <b>longer</b> on high <b>blood</b> pressure medicine and do not have sleep apnea (CPAP machine no <b>longer</b> needed)."</li> <li>• "I now have a <b>longer</b> life expectancy. I get to have the chance to see my daughter grow up and get married and have a family of her own."</li> <li>• "All of my lab results have been markedly improved. I am <b>healthier</b> than I have probably ever been in my entire life."</li> <li>• "<b>Healthier</b>. Lower blood pressure, lower blood sugar, lower <b>cholesterol</b>."</li> <li>• "I no <b>longer</b> have to take high <b>blood</b> pressure medicine or high <b>cholesterol</b> medications. I was also no <b>longer</b> borderline <b>diabetes</b>."</li> </ul>
<b>Positive affect (18.5%)</b> Feel (178/0.055) Eat (156/0.052) Body (108/0.036) Appear (66/0.020) Comfort (82/0.026) Control (58/0.016) Life (200/0.012)	<ul style="list-style-type: none"> <li>• "My overall attitude about myself. I cannot stress how much better I <b>feel</b> mentally and that effects every aspect of my <b>life</b>. I am talking about a '<b>feeling</b>' of power, or being alive, of mental well-being."</li> <li>• "My outlook is healthy, educated, and full of constant awareness and intention. I see health as more than what I <b>eat</b>. It is food, activity, exercise, sleep, and self-care, which are all equally important. I see food as nourishment that fuels my <b>body</b> to let me do the things that I want and live the <b>life</b> that I want. It's something I have total <b>control</b> over, and I take total ownership for all choices, healthy or less healthy. <b>Feeling</b> in <b>control</b> about food, by seeing things as MY CHOICE, and having a different attitude about MY food/weight affects every decision in my <b>life</b>."</li> <li>• "I feel more <b>comfortable</b> in my skin and this peace has made me more <b>comfortable</b> in the world. This has many rewards."</li> <li>• "I feel much more <b>comfortable</b> in my <b>body</b>. I feel that my <b>body/appearance</b> is the 'real' me."</li> </ul>

Abbreviation: CPAP, continuous positive airway pressure.

<sup>a</sup>% responses indicate the proportion of the responses reflected in the topic.

<sup>b</sup>Weighted probabilities indicate the extent to which a word is uniquely associated with a topic; although words within each topic were not analyzed jointly, they clustered in responses and shared a unique association with the same topic. Results are from analysis with stemming. This is not an exhaustive list of the 20 words extracted for each topic. Shown are the most frequent (>50) and highly weighted words in each topic.



**TABLE 7** Topics and representative quotes from weight-loss maintainers ( $n = 4,761$ ) who responded to the following question: "Please describe any negative consequences of successful weight loss."

Topics (% responses) <sup>a</sup> Words (frequency/ weighted probabilities) <sup>b</sup>	Representative quotes
Clothing and criticism (38.3%) Clothing (582/0.073) People (359/0.039) Eat (358/0.039) Buy (310/0.038) Money (172/0.022) Friend (154/0.020) Time (132/0.015)	<ul style="list-style-type: none"> <li>• "Needing to <b>buy</b> new <b>clothes</b>. I wasn't working when I started my first loss journey, and I had to suffer for months wearing <b>clothes</b> that were way too big until I could save enough <b>money</b> to start replacing."</li> <li>• "<b>Clothing</b> doesn't fit. <b>People</b> don't recognize me."</li> <li>• "<b>People</b> act as though I have changed but I'm the same person inside; my personality didn't change. I was always a good person. but now they see me differently and treat me differently. I think it's sad that society treats heavy <b>people</b> so poorly. We are all beautiful and worthy of simple human respect."</li> <li>• "<b>People</b> scrutinize what I'm <b>eating</b>."</li> <li>• "<b>People</b> have a tendency to comment or criticize what I <b>eat</b> or don't <b>eat</b>. They do not realize how hurtful it can be. I don't like going out with certain <b>people</b> because they usually have comments."</li> <li>• "Those that are close to you may separate themselves from your <b>friendship</b> because of your changed <b>eating</b> habits. Can be deflating emotionally."</li> <li>• "I spend much more <b>time</b> thinking about food choices/nutrition than I once did, which has resulted in needing to spend more <b>time</b> meal planning, grocery shopping, and meal prepping - this is <b>time</b> that I did not necessarily have, so I've had to 'borrow' it from other parts of my life. I feel that the tradeoff is worthwhile at this <b>time</b> in my life, and I am hopeful that as I form new habits and think of new prepping strategies, I will regain some of that 'borrowed' <b>time</b>."</li> </ul>
Skin and effort required (61.7%) Skin (516/0.063) Food (183/0.018) Back (159/0.018) Hard (139/0.016) Saggy (142/0.010)	<ul style="list-style-type: none"> <li>• "My body still isn't what I envisioned. My <b>skin</b> is loose, especially my stomach and breasts, which is <b>hard</b> to overcome..."</li> <li>• "I have a lot of extra <b>skin</b>, fat around the abdomen and knees that won't go away despite any amount of time at the gym. I chose to rise above that and be thankful for how great I look instead of being negative about what's not perfect about me. I realize that with that amount of a weight loss, I would need surgery to get rid of anything extra that I haven't been able to tighten up."</li> <li>• "There are certain areas of my body that are <b>saggy</b> due to being overweight for the majority of my life. There are some things that only surgery can fix and that's not an option."</li> <li>• "I will never be <b>back</b> where I was when I never had to think about <b>food</b> or activity."</li> </ul>

<sup>a</sup>% responses indicate the proportion of the responses reflected in the topic.

<sup>b</sup>Weighted probabilities indicate the extent to which a word is uniquely associated with a topic; although words within each topic were not analyzed jointly, they clustered in responses and shared a unique association with the same topic. Results are from analysis with stemming. This is not an exhaustive list of the 20 words extracted for each topic. Shown are the most frequent (>100) and highly weighted words in each topic.

Self-monitoring has long been considered a core component of standard behavioral obesity treatment, and most evidence-based treatment approaches, including the WW program, encourage tracking. In the current study, the term "lifestyle" was closely tied to tracking, encouraging people to see tracking and other health behaviors as part of necessary lifestyle changes. One long-term weight-loss maintainer advised that "you have to get up every day and make a choice to track and eat right. It is going to be difficult and there will be days that you will fall, but you can get back up and keep moving forward. This is a lifestyle change, not a diet."

The statements describing consequences of weight-loss maintenance were resoundingly positive; participants described how weight-loss maintenance had transformed nearly every facet of their lives, including self-confidence, pain, fitness and mobility, medical status, and affect. For some, these positive improvements served as an ongoing source of motivation: "This is something that is hard fought and hard won and something that will keep me motivated for the future." Although positive rewards outweighed negative ones, there were some common negative consequences of weight-loss maintenance, including the expense of having to buy a new wardrobe and body-image concerns related to having saggy skin.

This study is the first, to our knowledge, to use machine learning and topic modeling to analyze textual responses of over 6,000 long-term weight-loss maintainers describing their motivations, strategies, and consequences of weight-loss maintenance. The use of an unsupervised, machine-learning approach allowed for efficient analysis and identification of broad themes in a large volume textual data set. Advantages of an unsupervised method is the opportunity for researchers to discover themes that might have been missed through human-supervised methods. Novel themes that emerged included the role of remembering painful experiences as a motivator and the concept of perseverance. Although powerful themes emerged, there were several other topics that were more scattered that did not easily converge, underscoring a rich diversity of individual experiences and pathways to long-term successful weight management. One weight-loss maintainer wrote "Everyone's journey is a unique education into learning about oneself and what works for your lifestyle. Self-discovery takes a while, so don't give up!"

This study also has several limitations. Even unsupervised, machine-learning approaches have subjective elements that can lead to a biased point of view (35). The number and label assignment of quantitatively derived themes in this study were, to some extent, subjective, and research is still emerging on optimal ways to

choose the proper number of topics in a model beyond a major iterative approach (36). Because this was an unsupervised approach, the positive and negative valiance of some topics were unclear (e.g., social prompts for weight loss reflected both positive and emotionally hurtful social experiences). We examined term frequency and probability weights but did not examine word vectors (cluster bag of words) or skip grams (in which a word predicts surrounding words). Future research is needed using validated measures of the topics and themes identified in this study, including perseverance, motivation, stigmatization, and health-related quality of life.

Another major limitation in the current study is that participants were predominantly White, female, married, educated, and with at least midlevel income. Also, within the WWSR cohort, people who chose versus those who did not choose to complete the open-ended questions were more likely to be White. Therefore, findings from this study may only generalize to a primarily White subset of the population of weight-loss maintainers. This is a significant study weakness because the prevalence of obesity and related comorbidities is highest in more socially disadvantaged groups, including people of color who have less education and income. It is likely that the prioritized themes might differ based on these and other characteristics that were not examined in the current study. Moreover, the experiences reported among participants in this study might not align with those who could not afford the WW program or those who lost weight via other programs or self-selected means. Future research is needed to understand the motivations, strategies, and experiences of weight-loss maintainers from different race/ethnicities and socioeconomic backgrounds and those from different programs, as well as those with varying degrees of weight loss.

In conclusion, this topic analysis suggested that weight-loss maintainers in WW were commonly motivated by health and appearance concerns and that they experienced profound improvements in these and other domains as a result of weight-management efforts. Future weight-maintenance research should include more diverse populations and investigate the importance of promoting perseverance in the face of setbacks, sustained tracking, and making changes in medical status more salient during the weight-maintenance journey. Societal level interventions that confront a prevailing sociocultural climate in which weight-based self-esteem and discrimination persist are needed. Although common themes emerged from the experiences of more than 6,000 weight-loss maintainers, unique pathways were also described in the lives of those engaged in the ongoing process of weight-loss maintenance.○

#### CONFLICT OF INTEREST

SP reports receiving a research grant from WW International, Inc. MIC and GDF are current employees and shareholders of WW International, Inc. The other authors declared no conflict of interest.

#### AUTHOR CONTRIBUTIONS

SP had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: SP, JR, HG, and GDF; analysis and interpretation of data: HG, JR, SP, and SMN; data collection and management: NA; drafting of the manuscript: JR, SMN, and SP; critical revision of the manuscript for important intellectual content: SP, MIC, and GDF; administrative, technical, or material support: NA; and study supervision: SP.

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