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Original Article

Process Evaluation of a Mobile Weight Loss Intervention for Truck Drivers

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ABSTRACT

Background: In a cluster-randomized trial, the Safety and Health Involvement For Truck drivers intervention produced statistically significant and medically meaningful weight loss at 6 months (−3.31 kg between-group difference). The current manuscript evaluates the relative impact of intervention components on study outcomes among participants in the intervention condition who reported for a post-intervention health assessment ($n = 134$) to encourage the adoption of effective tactics and inform future replications, tailoring, and enhancements.

Methods: The Safety and Health Involvement For Truck drivers intervention was implemented in a Web-based computer and smartphone-accessible format and included a group weight loss competition and body weight and behavioral self-monitoring with feedback, computer-based training, and motivational interviewing. Indices were calculated to reflect engagement patterns for these components, and generalized linear models quantified predictive relationships between participation in intervention components and outcomes.

Results: Participants who completed the full program-defined dose of the intervention had significantly greater weight loss than those who did not. Behavioral self-monitoring, computer-based training, and health coaching were significant predictors of dietary changes, whereas behavioral and body weight self-monitoring was the only significant predictor of changes in physical activity. Behavioral and body weight self-monitoring was the strongest predictor of weight loss.

Conclusion: Web-based self-monitoring of body weight and health behaviors was a particularly impactful tactic in our mobile health intervention. Findings advance the science of behavior change in mobile health intervention delivery and inform the development of health programs for dispersed populations.

1. Introduction

Obesity is a serious problem for commercial truck drivers, with personal consequences and societal costs. Workplace environmental factors predispose truck drivers to obesity [1]. Drivers are largely physically inactive, have poor dietary habits, and experience deficits in sleep quality and quantity [2,3]. More than 90% of drivers are overweight or obese [4]. Compared to the general population, the prevalence of Class II obesity or greater [body mass index (BMI) 35+] is three times higher in male truck drivers and two times higher in female truck drivers [3]. As with any population, being overweight or obese is associated with a wide range of negative health consequences [5] and economic costs [6,7]. These are compounded by the dangers associated with driving large, heavy

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vehicles. There is a higher rate of crashes among obese truck drivers. For example, newly hired truck drivers who are obese have a 50% higher chance of a crash during their first 2 years of employment [8]. Obstructive sleep apnea, often associated with obesity, increases crash risk by two to five times relative to controls [9,10]. On a per-mile basis, truck drivers have a lower crash rate than civilian drivers, but fatalities are 20–55% more likely when a large truck is involved in a crash than passenger vehicles [11], largely due to the weight of the truck.

Commercial truck drivers present challenges for efforts to protect and promote their health. Owing to the dispersed nature of transportation operations, truck drivers are difficult to reach and cannot easily participate in traditional health promotion activities at physical worksites. To address this problem, the Safety and Health Involvement For Truck drivers (SHIFT) intervention used mobile technologies to provide drivers access to a tailored and effective weight loss and health promotion program [12,13]. This multicomponent intervention strategy incorporated evidence-based tactics that could be delivered in the context of the truck driving job structure and through modern technologies available to drivers. In a cluster-randomized controlled trial, the SHIFT intervention produced statistically significant weight loss at 6 months, with a between-group difference in body weight of −3.31 kg, $p < 0.001$.

Prior reviews of Internet-based weight loss interventions [14,15] found a lack of racial, gender, and economic diversity in target populations, predominantly involving Caucasian, female, and middle-class participants. These reviews also indicate that evaluations of interventions typically focus on engagement outcomes, not on identifying which intervention components were related to behavioral or weight loss outcomes. The current process evaluation of the SHIFT program addresses some of these gaps by investigating the relative impact of the components of a mobile health intervention for an isolated and predominantly male workforce. The current analyses were designed to inform companies that may consider whole or partial intervention adoption and to guide future replications, tailoring, and enhancements to maximize intervention effectiveness and reach. Mobile health promotion efforts can be advanced by such studies that define the impact of specific program components and the groups most likely to benefit.

2. Materials and methods

The SHIFT intervention consisted of five interactive and interrelated components (described in detail in the following): (1) a group weight loss competition with incentives, (2) self-monitoring via a website on which participants set goals and tracked their behaviors, weight, and intervention participation, (3) training on healthy weight loss, diet, exercise, and sleep, (4) motivational interviewing to reinforce training and increase motivation for behavior change, and (5) an individual certification process with incentives to increase program engagement.

2.1. Theoretical and conceptual approach

The intervention was informed by the ecological perspective of health promotion, the social cognitive theory of self-regulation, and reinforcement or operant theory. The ecological perspective emphasizes interactions between different levels of a health problem, including organizational, interpersonal, and intrapersonal levels [16]. The intervention was designed to impact interpersonal factors by creating squads to foster social support in a weight loss competition and to impact intrapersonal factors by increasing knowledge and self-efficacy through computer-based training, behavioral self-monitoring, and motivational interviewing. At the intrapersonal level, drivers were encouraged to make changes to their cab environment and utilize self-management strategies to make target behaviors more probable. A competition format was chosen due to its potential effectiveness for weight loss [17], particular effectiveness with males [18], and consistency with our theoretical and conceptual approach. Motivational interviewing also impacts interpersonal and intrapersonal factors by nurturing an individual's goal-directed motivation, advancing movement toward behavior change, and discussing an individual's reasons for and against behavior change. The approach is client centered, and coaches are trained to develop a spirit of collaboration that is supportive of client autonomy [19].

Intervention tactics were also informed by Bandura's social cognitive theory of self-regulation [20] and were designed to generate motivation and enhance self-efficacy for engaging in targeted behaviors. In this theory, self-regulatory motivation is said to be driven by self-observed motivating discrepancies between current and personal or social standards for behaviors. The intervention addressed these factors through social comparison feedback in the weight loss competition, behavioral self-monitoring in which personal habits were compared to goal standards, training to improve drivers' knowledge and confidence in making changes, and motivational interviewing calls that supported driver self-efficacy while exploring gaps between participants' current and desired health states. Self-monitoring was also chosen because it is often included in weight loss interventions [14] and is associated with greater weight loss [21]. Reinforcement or operant theory [22] provided further guidance in intervention design through the application of behavioral principles in computer-based training (frequent quizzes, self-pacing, mastery required to advance) and through individual and group technical, social, and incentive consequences for participation and achievement.

From its inception [12], the SHIFT program also adopted an integrated view of interactions among health and safety factors for workers, which is consistent with the emerging *Total Worker Health*® (TWH) approach. The National Institute for Occupational Safety and Health defines the TWH approach as "policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being" [23]. The strategic priority from the TWH perspective is to alter working conditions to protect and advance worker safety, health, and well-being. In the SHIFT study, organizational factors were leveraged to support driver participation in preintervention and post-intervention health screenings. Operations leaders and dispatchers received briefings on the project, sent scheduled recruitment and reminder messages to drivers via in-cab satellite text messaging, and coordinated driver schedules to attend testing periods. Design of intervention components (study website, computer-based training, and health coaching) and recommendations for behavior change also considered occupational constraints and how drivers would access the intervention. Computer-based training topics integrated cross-cutting TWH-related themes, including the impact of work on health and safety; the impact of health conditions on well-being and safety; and interactions between sleep, eating, and exercise behaviors.

2.2. Design of the randomized controlled trial

A full description of the original study design, Consolidated Standards of Reporting Trials diagram, and 6-month outcomes have been reported [24]. Institutional Five trucking companies participated in the study, and 452 drivers from 22 trucking terminals within these five companies were enrolled. Terminals within each company were paired based on terminal characteristics, and one

Table 1
Summary of SHIFT intervention components and content

Component	Subcomponent	Content description
Website-Based Weight Loss Competition	Individual-level weight loss and behavioral feedback	Each participant's website profile page (landing page upon login) included three types of feedback that were updated in real time each time a participant submitted a behavioral self-monitoring log. A graphic of a semi-truck housed a bar graph that represented the participant's overall progress to his/her weight loss goal, displayed in overall pounds lost and percent of goal achieved. A second graph displayed a permanent line that indicated the trajectory that the participant needed to stay on to achieve his/her weight loss goal. Each time a participant submitted a log, a dot appeared on the graph indicating his/her body weight, which allowed the person to see his/her progress relative to the trajectory line. A table displayed the behavioral goals that the participant selected. With each log that a participant submitted, the number of days that the person reported meeting his/her behavioral goals in the previous week was updated, along with the participant's best week and the cumulative number of days that the participant had reached his/her behavioral goals.
	Individual-level certification progress feedback	A second page within a participant's profile displayed progress toward earning SHIFT certification. Graphic gauges that resembled tachometers were used to display the number of logs that the participant submitted, the number of trainings completed, and the number of coaching calls completed. A green line area was used in place of a typical red line area to indicate the level needed to achieve certification.
	Social comparison feedback	Each participant could view weight loss and certification progress for other individuals within his/her weight loss squad. In addition, a competition status page showed percent goal achieved for each squad in the competition. Within-squad individual results were rank ordered by percent goal achieved, and between-squad group results were rank ordered by group-level percent goal achieved.
Body Weight and Behavioral Self-Monitoring	26 potential weekly logs over the 6-month intervention	Self-monitoring of body weight plus behaviors in the domains of diet, exercise, and sleep. Participants could choose which behaviors they wanted to track from a menu of options. Specific behavior options included reducing a high-calorie diet habit; reducing portion sizes; eating more fruits and vegetables; walking or exercising 30 minutes a day; and sleeping for 7–8 hours. Feedback for body weight included a truck that filled in as the user progressed toward his/her weight loss goal and a line graph showing his/her weight loss trajectory relative to a goal line. Cumulative behavioral feedback was also displayed as the number of days participants reached his/her behavioral goals
Computer-Based Training	Orientation	Introduction to program goals and structure, description of intervention activities, how to earn SHIFT certification, and description of resources available to participants.
	SHIFT 10%	Designed to help drivers think about and begin forming their own strategies for success. Content focused on sustainable weight loss and how small daily changes can have big long-term impacts on weight and health. Specific topics were as follows: Review of SHIFT Intervention; How Body Weight Impacts DOT Medical Certificate Conditions; How to Lose 10% in a Healthy Way; How to Make Changes in Behavior
	SHIFT Eating	Designed to help drivers find the shortest route to eating and feeling better. The focus was on how food and drink impact weight and health, including tips and strategies that have worked for other drivers. Specific topics were as follows: Calorie Balance and the SHIFT Eating Behavior Change Menu of Options; Whole vs. Processed Foods and Label Reading; Nutrition 101; Eating Tips for Truck Drivers
	SHIFT Exercise	Provided information about types of physical activity and the many mental and physical health benefits. Content focused on activities that are accessible for drivers, such as walking, strength training, and stretching. The specific topics were as follows: Calorie Balance Review; Exercise Overview; Exercise Routines for Truck Drivers in and Around the Truck; Strategies for Exercising on the Road.
	SHIFT Sleep	Designed to inform drivers about the importance of adequate sleep and the connections between sleep, eating, exercise, and body weight. Specific topics were as follows: The Sleep, Eat, and Exercise Wheel; Sleep Impacts on Disease and Safety; Circadian Rhythms and Sleep Cycles; SHIFT Sleep and Fatigue Tips
Health Coaching Calls	Call#1 30–45 minutes	Session goals: 1) introduce participant to health coaching, 2) explore the client's weight loss goal, 3) understand what they are currently doing to support their health, 4) understand their perceived challenges in reaching their goal, and 5) elicit reasons for the health behavior change and 6) ideas for ways they can implement behavioral changes from the SHIFT Menu of Options. For participants who were ready, a detailed change plan was made, and the coach invited drivers to make commitments to making changes.
	Call#2 15–20 minutes	Session goals: 1) review the participant's goals from the first session, 2) explore barriers and successes between the first and second sessions, 3) encourage motivation to sustain good behaviors and create new goals, 4) explore new directions for changing or maintaining healthy behaviors, and 5) invite drivers to explore change in multiple goal areas (i.e., eating AND exercise).
	Call#3 15–20 minutes	Session goals: 1) review the participant's preestablished goals from the second session, 2) explore barriers and successes, 3) encourage motivation to sustain good behaviors and create new goals, and 4) determine the client's intervention status (e.g., training module completion, health logs, etc.).
	Call#4 15–20 minutes	Session goals: 1) review the participant's preestablished goals, 2) explore barriers and successes, and 3) encourage motivation to maintain positive behaviors beyond the end of the program. For participants who expressed frustration about not reaching their weight loss goals, the health coach offered the opportunity to set a short-term weight loss goal for the remaining weeks of the intervention.

terminal from each pair was randomly assigned to the intervention, whereas the other was assigned to the control condition. Inclusion criteria for drivers were a BMI of at least 27 kg/m^2, an interest in losing weight, and the absence of contraindicating medical conditions. Research staff traveled to participating terminals where drivers enrolled in the study. Program incentives were $40 for baseline enrollment and $80 for completing the postintervention survey and health assessment. The current analyses include only participants in the intervention condition who completed the 6-month follow-up assessment ($n = 134$).

2.3. Intervention components

Immediately after enrollment, intervention drivers completed a short orientation training, created a study website profile, set a weight loss goal of 8, 10, or 12% of initial body weight, and scheduled their first motivational interviewing call. Drivers were informed of an estimated daily calorie deficit needed to achieve their weight loss goal and given resources to support program participation (resource book, business card with website login and tech support contact info, etc.). Drivers were assigned to a weight loss squad with other drivers from their terminal and given instructions for intervention participation. Although most participants accessed the Web-based components of the intervention with personal computers and smartphones, each intervention terminal was given a stationary laptop that drivers could use while visiting the terminal and a laptop with a WiFi card which drivers could check out and take with them on the road.

2.3.1. Group weight loss competition

The SHIFT website facilitated a weight loss competition in which squads within each company competed to achieve the highest percentage of their weight loss goals. Percent of goal achieved was chosen as the competition standard to encourage a healthy pace of weight loss and to account for unequal squad sizes, variability in selected goal levels, and the possibility that squads with higher starting body weights would have more weight to lose. The site featured feedback on individual-level weight loss, behavioral goals, and intervention participation, as well as within-squad and between-squad social comparison feedback (see Table 1 for details). Because truck drivers are highly dispersed, the site also featured forums where squad members could virtually interact and provide social support. Each member of the squad that won a weight loss competition received a gift card and a work jacket embroidered with the SHIFT study logo.

2.3.2. Behavioral and body weight self-monitoring

Drivers were asked to submit weekly self-monitoring logs of their body weight and diet, exercise, and sleep behaviors on the study website (26 possible logs for the 6-month study; see Table 1). Self-monitoring behavioral goal options included the following: stop or reduce a high-calorie diet habit, reduce portion sizes, eat more fruits and vegetable servings, walk (or do other similar exercise) on at least 4 days each week, and sleep 7–8 hours each day. In each log, drivers reported their body weight plus days in the past week during which they met each behavioral goal and feedback charts updated in real time when drivers submitted a log. For process analyses in this manuscript, the number of logs completed and the timing of log completion were computed for each participant.

2.3.3. Computer-based training

Training content was presented on a computer-based instruction platform (cTRAIN learning platform NwETA.com, Lake Oswego, OR) that has been effective in delivering occupational content for diverse worker groups [25–27], including a pilot study of the SHIFT intervention [12]. In addition to the initial orientation, training topics targeted healthy weight loss principles and three modifiable primary health behaviors that impact body weight (nutrition, physical activity, and sleep; see Table 1). Training units were tailored for truck drivers and their environment, including testimonial interview videos with truck drivers who had personal experiences and tips to share, video demonstrations of exercises that can be accomplished in and around the cab of a truck, sleep hygiene behavioral recommendations tailored to the cab environment, and dietary behavior recommendations relating to eating healthy while on the road (e.g., packing a cooler or fridge with home-cooked meals, fruits, and vegetables that might not be accessible while away from home). Each unit's overarching goals were to provide evidence-based information concerning the topic and self-management strategies to successfully change behavior and lose weight and were designed to be completed in approximately 20–45 minutes. For process analyses, the number and timing of training units completed were computed for each participant. Knowledge gains for each training were also generated from pre-test/posttest incorporated in the training platform.

Table 2
Sample baseline characteristics

Variables	*n*	Mean (SD) or %
Age	130	49.24 (11.19)
Sex (Male)	134	86.76
Married/Living with a partner	134	61.94
Education	123	
HS diploma or GED		57.72
Vocational/technical certificate		20.33
Associates degree		12.20
Bachelor's degree		7.32
Graduate degree		2.44
Weekly work hours	130	
0–54.99		23.85
55–64.99		34.62
≥65		41.54
Tenure as truck driver (yrs)	134	13.30 (10.42)
Tenure current company (yrs)	134	
<1		28.36
1–2.49		16.42
2.5–4.99		13.43
≥5		41.79

SD, standard deviation.

2.3.4. Motivational interviewing

Drivers completed up to four health coaching phone calls with a health coach trained in motivational interviewing. Researchers collaborated with the four project health coaches to develop a SHIFT-specific health coaching protocol for each of the four potential calls (see Table 1 for details). The first call was typically scheduled within 2 weeks of enrollment; subsequent calls were spaced according to driver preference (typically about 4 weeks apart). Coaching adhered to all relevant federal and corporate cell phone safety laws and policies for commercial truck drivers. A lead coach supervised the process and monitored adherence to motivational interviewing technique. For process analyses in this article, the total number of calls completed was used for each driver.

2.3.5. SHIFT certification

SHIFT certification offered individuals a chance to succeed independently from their squad's performance in the weight loss competition by achieving full participation in all intervention components. Certification incentives included a signed certificate of completion and a $100 gift card to a sporting goods store. The criteria for achieving certification were as follows: completing 15 or

Table 3
Raw mean and sample size for primary intervention outcome measures

Outcome	Baseline			6 months			Mean change
	N	M	SD	N	M	SD	
Body weight (lbs)	134	251.67	60.81	134	246.32	62.23	−5.35
Body weight (kg)	134	114.15	27.58	134	111.73	28.23	−2.42
Body mass index	134	37.02	7.81	134	36.28	8.06	−0.74
Daily fruit/veg. servings	134	2.51	2.38	127	3.03	2.69	0.52
Physical activity*	134	1.16	1.14	126	1.92	1.31	0.76

SD, standard deviation.
**Note*. Physical activity was scored as the mean of four questions assessing days per week (0 to 7) with moderate or vigorous aerobic activity or strength training.

more of the 26 self-monitoring logs, all four training units, and all four coaching calls. For process evaluation analyses, SHIFT certification was coded as a yes/no variable.

2.4. Analyses

Descriptions of the full range of measures collected in the study have been published [2,24]. This process evaluation focuses on the three primary outcomes that changed significantly in the randomized trial: body weight, fruit and vegetable consumption, and physical activity. All measures in these analyses were collected at baseline and 6-month (postintervention) health assessments. Body weight was measured objectively by researchers (Tanita TBF-310GS scale; Tanita Corporation, Tokyo, Japan), and surveys were used to measure fruit and vegetable consumption [28] and physical activity [29]. Sample characteristics (see Table 2) and outcome statistics (see Table 3) were computed todescribe the participants in this sample ($N = 134$). To account for the nesting of drivers within terminals, general estimating equations (GEEs) were used in regression models of intervention participation on program outcomes. These models examined the relationships between process variables (trainings, coaching sessions, and self-monitoring logs) and the outcomes of body weight (kg), fruit and vegetable consumption, and physical activity. Examination of outcome distributions revealed that the fruit and vegetable consumption distribution was positively skewed with a variance considerably larger than its mean, indicating overdispersion, and a negative binomial model was used for this outcome. All other outcome variables were normally distributed, and typical GEE models were applied. Three sets of models were run for each outcome. In the primary set of models, we entered each of the continuous process variables in a separate model to examine the independent relationship between each process variable and change in outcomes from baseline to 6 months. These models included the continuous count process variable, time (baseline and 6 months), and the interaction of process variable by time, which was the effect of interest. Then, a set of models including all of the continuous process variables were run simultaneously to look at the unique contribution of each variable on change over time in each of the outcomes. Finally, the process variables were recoded into dichotomous variables, which were determined *a priori*: trainings (0–3 vs 4), coaching sessions (0–3 vs 4), and logs (0–14 vs 15 or more), and entered into outcome models one at a time to evaluate the impact of certification criteria.

3. Results

3.1. Baseline characteristics

The majority of participants were male (87%), with a mean age of 49.24 years [standard deviation (SD) = 11.19]. Most reported high school (58%) as their highest level of education, with the next highest proportion reporting an additional vocational/technical certificate (20%). Most of the intervention participants were married or partnered (62%). On average, participants had been truck drivers for 13 years, with 41% working for 5 or more years with their current employer. Long hours were the norm with 76% working 55 or more a week.

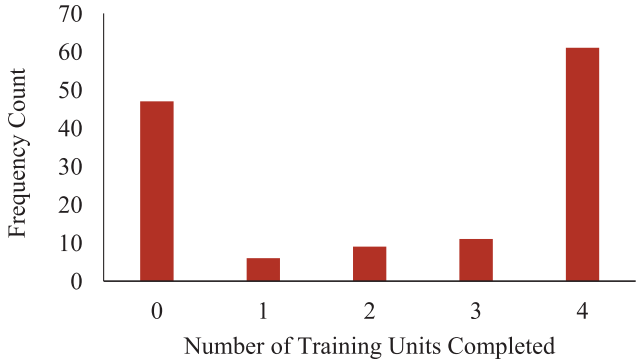

Fig. 1. Training units completed by intervention participants.

3.2. Intervention engagement

Of the 134 drivers in the current sample, 34 earned SHIFT certification by completing the full intended dose of the intervention, 97 completed a portion of intervention activities, and 3 did not participate after orientation outside of returning for the 6-month assessment. Certification attainment did not have a significant relationship with squad membership (Fisher's exact test = 10.83, $p = 0.73$). On average, drivers completed 2.25 of four possible training units (SD = 1.82), 3.27 of four possible motivational interviewing calls (SD = 1.23), and submitted 8.65 of 26 possible (SD = 7.65) behavior and body weight logs (see frequency distributions in Figs. 1–3). Knowledge gains measured by computer-based training pre–post tests were very large (mean $d = 2.01$; range 1.87–2.69). Earning SHIFT certification was associated with significantly greater weight loss (5.36 kg vs. 1.43 kg for noncertified drivers; GEE analysis $p < 0.001$). Engagement in computer-based training was highest during the first 3 weeks after enrollment (see Fig. 4), and more than twice as many participants accessed the website and training by a computer than by a tablet or smartphone.

3.3. GEE models: body weight

When examined independently, increases in each of the three count process variables were significantly related to a decrement in weight (see Table 4). Each additional training completed was

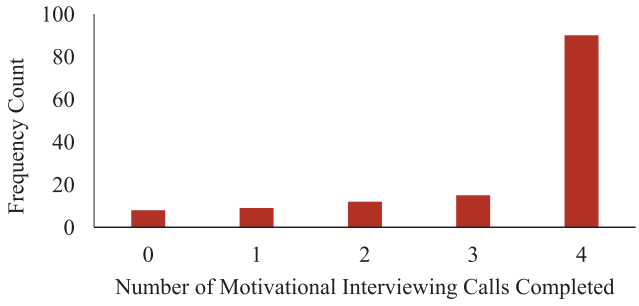

Fig. 2. Motivational interviewing calls completed by participants.

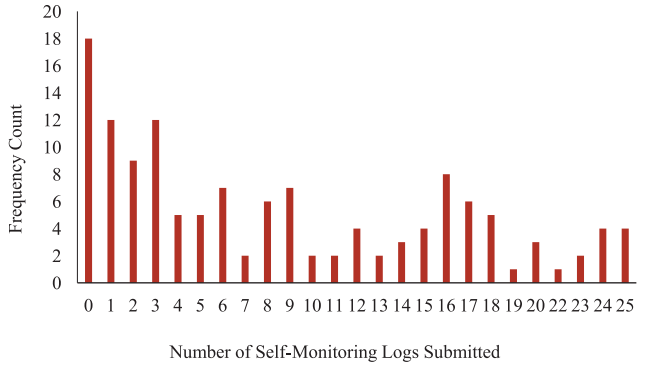

Fig. 3. Body weight and behavior self-monitoring logs submitted by intervention participants.

associated with a 0.81-kg decrease in body weight ($b = -0.81$, $p < 0.001$); for each additional coaching session completed, body weight decreased by 1.09 kg ($b = -1.09$, $p < 0.001$); and each additional log submitted was associated with a 0.30-kg reduction in body weight ($b = -0.30$, $p < 0.001$). In models with the process variables entered simultaneously, only self-monitoring logs explained unique variance related to a decrement in body weight. For each additional log completed, intervention participants lost 0.29 kg. ($b = -0.29$, $p = 0.004$).

GEE analyses of recoded dichotomous process variables revealed that meeting each certification criterion (four trainings, four coaching sessions, and 15–26 self-monitoring logs) was associated with significantly more weight loss. Completing all four trainings was associated with a 2.87 kg ($b = -2.87$, $p = 0.001$) greater decrease in body weight than completing three or fewer trainings. Participants who completed all four coaching sessions lost 3.07 kg ($b = -3.07$, $p < 0.001$) more than those who completed three or fewer. Submitting 15+ self-monitoring logs was associated with a 5.34 kg ($b = -5.34$, $p < 0.001$) greater reduction in body weight than in those who submitted 14 or fewer logs.

3.4. GEE models: fruit and vegetable consumption

Outcomes of GEE models for fruit and vegetable consumption were similar to those for body weight. When entered individually, increases in each of the count process variables was associated with greater fruit and vegetable consumption (see Table 4). For each additional training completed, average daily servings of fruit and vegetables increased by 0.10 ($b = 0.10$, $p = 0.039$). For each additional coaching session completed, daily servings increased by 0.22 ($b = 0.22$, $p < 0.001$). For each additional log completed, daily

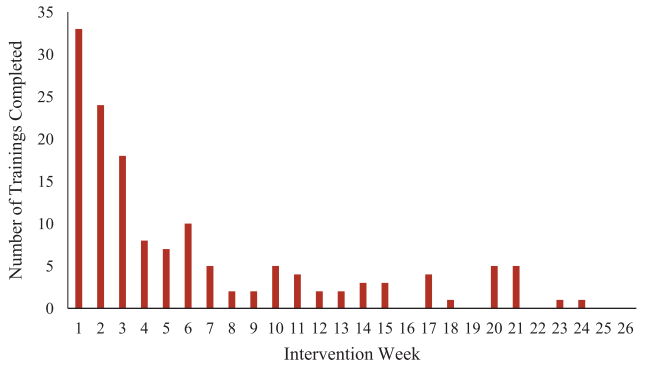

Fig. 4. Timing of trainings completion by intervention participants.

Table 4
GEE coefficients for the independent effects of process variables on change in outcomes from baseline to 6 months

	Weight (kg)		Daily fruit/veg. servings*		Days/week with 30-min physical activity	
	Coeff.	*p*	Coeff.	*p*	Coeff.	*p*
# of trainings	−0.81	<0.001	0.10	0.039	0.06	0.334
# of coaching calls	−1.09	<0.001	0.22	<0.001	0.03	0.784
# of self-monitoring logs	−0.30	<0.001	0.04	0.001	0.03	0.072

Note. *Negative binomial distribution.

servings increased by 0.04 ($b = 0.04$, $p < 0.001$). When entered simultaneously, only the number of coaching sessions was significantly related to increases in fruit and vegetable consumption, explaining unique variance in this outcome. In this combined model, each additional coaching session completed was associated with a 0.17 increase in daily servings of fruits and vegetables ($b = 0.17$, $p = 0.002$).

When examining each of the dichotomous categorical process variables independently, those who met certification criteria for coaching sessions and self-monitoring logs showed significantly greater increases in fruit and vegetable consumption than those who did not meet the criteria. Those who completed four coaching calls ate 0.53 ($b = 0.53$, $p < 0.001$) more servings of fruits and vegetables per day than those who did not meet the criteria. Those who met the criteria for self-monitoring logs ate 0.58 more servings ($b = 0.58$, $p = 0.011$) per day than those who did not meet the criterion. There was no significant difference in fruit and vegetable consumption based on the training criterion.

3.5. GEE models: physical activity

None of the count process variables were significant predictors of changes in physical activity. This was true when examining the process variables in individual GEE models and when entering them simultaneously. However, when examining the dichotomous categorical process variables in single predictor models, submitting 15+ self-monitoring logs was associated with 0.79 ($b = 0.79$, $p = 0.002$) more days of physical activity per week than recording 14 or fewer logs. None of the other categorical variables were significantly related to changes in physical activity.

4. Discussion

To our knowledge, the SHIFT study is one of the only two randomized controlled trials of a weight loss program for truck drivers to observe a statistically significant and medically meaningful reduction in body weight [24,30]. The study population is unique in terms of intervention delivery, and the process analyses of the effectiveness of intervention components are valuable for tailoring interventions for truck drivers and other commercial drivers, and for mobile-delivered health promotion interventions in general. These results also have implications for interventions with other mobile populations and lone workers that are predominantly male, such as migrant workers, members of the military, or commercial seamen and fishermen.

Completing the study-defined full dose of the intervention, recognized by earning SHIFT certification, was highly impactful. Drivers who completed this dose (15+ body weight and behavior self-monitoring logs, four motivational interviewing calls, and four training units) lost an average of 5.36 kg in the 6-month intervention compared with 1.43 kg for drivers who completed part

or none of the intended dose. The magnitude of weight loss for certified participants is similar to certified participants in the SHIFT pilot study [12]. Taken together, this suggests that the certification criteria were set at meaningful levels. Earning certification was incentivized with a $100 gift card to a sporting goods store, and in the current sample, 25.4% of drivers who were able to report for 6-month testing (34/134) earned certification. The level of weight loss among certified drivers is equivalent to nearly 2.0 BMI units, which is predicted to save $400 per person per year in health-care costs [6]. Given the impact of certification and the expected cost savings, it may be worthwhile to increase certification incentives to motivate more drivers to achieve these levels of participation.

While earning certification was highly impactful, individual intervention components were also meaningful. When process variables were examined as independent predictors in GEE models, all process variables were significant predictors of change in body weight; motivational interviewing and logging were significant predictors of increases in fruit and vegetable consumption, and no process variables were significant predictors of changes in physical activity. However, when logging was transformed into a binary categorical variable (met/did not meet certification criteria of submitting 15 logs), logging was a significant predictor of changes in physical activity. Taken together, these findings indicate that all intervention components were impactful for behavior change.

Body weight and behavioral self-monitoring appears to have a unique level of importance to the intervention. This finding supports prior literature showing that more frequent self-monitoring is related to greater weight loss [21]. Self-monitoring is a rich process that involves observing, evaluating, and recording dimensions of one's own behavior. Participants were also encouraged to engage in self-management tactics to cue behaviors or provide self-reinforcement for engaging in them. Our intervention process used self-monitoring data to generate feedback for participants on their current levels of behavior and weight relative to personal and squad goals. According to Bandura, such discrepancies between current behaviors and goals or social standards are the locus of self-regulated motivation [20]. Feedback on program participation levels and squad ranks in the competition may have also functioned as conditioned reinforcement for logging as participation and competition outcomes could have been personally valued by drivers and were also linked to incentives. These factors are likely relevant to the unique impact logging had on body weight and changes in dietary and exercise behaviors in the SHIFT program. It is also important to note that behavior and body weight logging was implemented in a way that was not overly demanding for truckers (weekly reporting), yet it was still particularly important for impacting outcomes, including body weight.

Motivational interviewing had a significant relationship with changes in fruit and vegetable consumption. Changing dietary behaviors, especially related to fruits and vegetable consumption, is challenging for truck drivers. Grocery stores are rarely located near major interstates where truck drivers spend most of their time, and drivers have a limited capacity to store fruits and vegetables in their cab. Given these challenges, the personal relationship and social accountability provided by health coaches and the motivational interviewing process may explain why motivational interviewing was related to changes in fruits and vegetable consumption.

The computer-based training units developed for the SHIFT program, which covered healthy weight loss, diet, exercise, and sleep, also had an effect on study outcomes. Based on GEE models, completing training alone did not appear sufficient to develop body weight and behavioral changes. Training effectiveness was maximized when paired with other activities, such as motivational interviewing and behavioral self-monitoring, that promote transfer of training into practical settings. To further enhance the effects of training, future interventions should experiment with a spaced training schedule in which shorter, more frequent training units are spread over time, or a spaced repetition training schedule in which participants complete an initial training and then repeat the information, along with new material, in short trainings spread over time. These schedules may improve long-term knowledge retention and have a greater impact on lifestyle behaviors and body weight.

4.1. Conclusions

The SHIFT program was designed to overcome barriers for health promotion among truck drivers and to take advantage of mobile health intervention strategies presented by modern technology. In a randomized controlled trial, the program produced significant weight loss in this group of lone, dispersed workers. Completing the full intended dose of the intervention was the biggest predictor of weight loss, and Web-based self-monitoring of body weight and health behaviors was identified as a particularly important predictor of both weight loss and behavior change in the intervention. These findings have implications for the development of health and safety programs for dispersed populations and advance the science of mobile-delivered health behavior and weight loss intervention delivery in general.

Ethical approval and consent to participate

The Oregon Health & Science University Institutional Review Board reviewed and approved all study procedures. All participants provided informed consent before enrolling.

Trial registration

NCT02105571; registration date: 02/28/2014; URL: https://clinicaltrials.gov/ct2/show/NCT02105571.

Conflicts of interest

OHSU and Dr Anger have a significant financial interest in NwETA, a company that may have a commercial interest in the results of this research and technology. This potential conflict was reviewed and managed by OHSU Conflict of Interest in Research Committee.

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Authors' contributions

B.W. was the primary author of this manuscript and the project manager for the randomized controlled trial described in the manuscript. G.H. completed the statistical analyses for this manuscript, wrote the Results section, and contributed to overall writing and editing. K.A., D.E., and T.B. are co-investigators who contributed to the design of the randomized trial, the interpretation of study findings, and writing and editing this manuscript. V.S. is a consultant on the randomized trial and contributed to refining intervention tactics and this manuscript. R.O. is the principal investigator of the SHIFT study, oversaw all study-related activities, and contributed to the writing and editing of this manuscript.

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