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The Vitality Active Rewards with Apple Watch Benefit: A follow-up study

An assessment of the benefit's effect on sustained physical activity

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Executive Summary

Background

The Vitality Active Rewards programme is a gain-framed incentive programme, in which Vitality members are provided with financial incentives for engaging in healthy behaviours, including physical activity, as measured by a wearable smart device. Since 2016, the Vitality Active Rewards with Apple Watch (VARAW), a loss-framed incentive, has been offered to Vitality Active Rewards programme members in the United Kingdom (UK). The VARAW benefit is offered on top of the Vitality Activity Rewards programme and thus provides members with both gain- and loss-framed incentives. As a part of the VARAW benefit, members purchase an Apple Watch, paying a small upfront deposit (c. 10% of retail price), plus monthly repayment amounts for the balance over 24 or 36 months that are linked to recorded physical activity levels and specific activity targets. Higher levels of physical activity and meeting activity targets result in lower monthly repayments. At the end of the 24- or 36-month period, members have the option to renew the benefit and purchase a new Apple Watch, with the loss-framed incentive repayment over 36 months, albeit members pay a larger deposit upfront for subsequent watches (c. 50% of retail price). In 2018, RAND Europe conducted an analysis of the impact of the VARAW benefit on physical activity outcomes among Vitality members in the UK; however, given that the benefit was relatively new, there was limited follow-up on members (average of approximately six months). We conducted the current longitudinal, observational study to examine longer-term physical activity impacts of the VARAW benefit.

Methods

Data were obtained from Vitality on UK members of the Vitality Activity Rewards programme, who were eligible for the VARAW benefit, from January 2016 to September 2022. Primary analyses were designed to assess whether uptake of the VARAW benefit was associated with changes in physical activity levels relative to the Vitality Active Rewards programme alone (i.e. pre-/never VARAW benefit) and if these effects were sustained after the first benefit expired. Secondary analyses were designed to assess whether subsequent renewal of the VARAW benefit was associated with changes in physical activity levels relative to effects observed from the first VARAW benefit. We also conducted exploratory sub-analyses to evaluate the effects of the VARAW benefit across all benefit periods compared with the before the first benefit period for members who renewed the benefit for a second and third time.

We used an interrupted time-series analysis approach to examine the relationships between VARAW benefit status over time and physical activity outcomes. Specifically, outcomes included the number of physical

activity days per month[1] (integer counts), which was modelled using negative binomial regression, and the proportion of high-level physical activity days per month (ranging from 0 to 1), which was modelled using an ordered logit regression. Models included statistical adjustment for gender and baseline body-mass index and smoking status, as well as calendar month and year from first recorded month of physical activity to the last. Standard errors were calculated using robust variance-covariance estimation with clustering by each member.

Results

A total of 660,212 Vitality Active Rewards programme members were eligible for the analysis, with 13,350,828 monthly observations and an average follow-up of 24 calendar months from first to last observation of physical activity in the dataset. Among these members, 172,301 (26.1%) accessed the VARAW benefit and 487,911 (73.9%) did not, with average calendar follow-up from first to last observation of approximately 33 and 21 months, respectively. Among those who accessed the benefit, 15,165 (8.8%) renewed the benefit for a second time and 894 (0.5%) renewed the benefit for a third time.

Our primary analyses showed that the first VARAW benefit was associated with a 40% average increase in physical activity days and a 64% average increase in odds of a higher proportion of high-level physical activity days. This effect was sustained, albeit to a lesser degree, after the first VARAW benefit expired. A decrease in physical activity of 15% was observed compared with when the first benefit was active; however, this was accompanied by a sustained level of high-level physical activity. Temporal trends showed a gradual decline in physical activity each month over time during and after the first VARAW benefit. Nevertheless, the period after the VARAW benefit expired was associated with an average 20% increase in physical activity days and an average 63% increase in odds of a higher proportion of high-level physical activity days compared with the pre-first VARAW period, or members who never accessed the benefit.

Our secondary analyses showed that second and third VARAW benefits were associated with an increase in the number of physical activity days (average increase by 13% and 11%, respectively) and odds of a higher proportion of high-level physical activity days (average increase by 40% and 46%, respectively) compared with the immediate periods prior, in which the benefits had expired (i.e. post-first benefit and post-second benefit, respectively). Relative to the first VARAW benefit the second and third benefits were associated with a decrease in the number of physical activity days (average decrease by 5% and 4%, respectively) but an increase in odds of a higher proportion of high-level physical activity days (average increase by 15% and 27%, respectively). Again, temporal trends within each period showed a gradual decline in physical activity levels each month over time.

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[1] Physical activity days are calculated based on the following thresholds: **low-level** (≥7,000 steps); **medium-level** (10,000 steps, ≥30 minutes of physical activity at 60% maximum heart rate, ≥30 minutes of physical activity at 300 kilocalories per hour, a gym workout, a park run or a digital at-home exercise class); **high-level** (≥12,500 steps, ≥60 minutes of physical activity at 60% maximum heart rate, ≥30 minutes at 70% maximum heart rate, 30 minutes of physical activity at 600 kilocalories per hour, 60 minutes of physical activity at 300 kilocalories per hour or a gym workout/park run/digital at-home workout in conjunction with additional steps, heart rate or calorie activity).

Exploratory sub-analyses show similar findings, with members who selected into a second VARAW benefit period having on average more physical activity days in the first benefit period compared with the pre-first benefit period, and these effects were sustained in subsequent periods albeit to a lesser degree. Similarly, high-level physical activity days increased in the first benefit period compared with the period before the first benefit and remained elevated or even increased into the second benefit period. Temporal trends showed gradual monthly declines in physical activity over time within each period, but levels of physical activity relative to the pre-first VARAW benefit remained positive. Findings for physical activity days were similar for members who selected into a third VARAW benefit, but limited effects were observed for high-level physical activity days, likely due to the small sample size.

Limitations

This study was conducted on a population of privately insured individuals and there may be limited generalisability to the UK population at large. Vitality members selected into the VARAW benefit, and they may differ from those who never accessed the programme and from those who selected into a second and third benefit in ways that are related to physical activity. We were unable to account for these factors in our statistical models. Thus, unmeasured confounding is likely, and causal inferences are limited. In addition, those selecting into the second and third VARAW benefits may differ from those who only accessed the first benefit. We expect that over time there will also be natural attrition of Vitality Activity Reward members if they are no longer insured with Vitality (e.g. in the case of switching employers). From these analyses we cannot discern effects of the VARAW benefit that are attributable to the loss- or gain-framed incentive or both, nor can we determine if the effects of the VARAW benefit were, alone, due to purchasing a new Apple Watch at a discount.

Conclusion

Findings from this longitudinal, observational study of Vitality Active Rewards programme members from the UK indicate that the first VARAW benefit is associated with an increase in physical activity days per month, as well as a higher proportion of high-level physical activity days, relative to before the start of the VARAW benefit or compared with never accessing the benefit. Furthermore, these associations appear to be sustained after the first VARAW benefit expires. Lastly, despite waning effects over time and a decrease in the number of physical activity days, a higher proportion of high-level physical activity days appears to be sustained with subsequent VARAW benefits, at least while these benefits are active. Taken together, these results suggest that, although the magnitude of increases in physical activity tend to be lower with each subsequent benefit, the overall effects on physical activity, especially the proportion of high-level physical activity, appear to be sustained over time.

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Abbreviations

BMI	Body-Mass Index
CI	Confidence intervals
IRR	Incident rate ratio
OR	Odds ratio
SD	Standard deviation
UK	United Kingdom
VARAW	Vitality Active Rewards with Apple Watch

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1. Background

Physical activity is well known to have positive effects on multiple health outcomes, including cardiovascular risk [1-3], diabetes [4, 5], cancer [6, 7], mental health [8, 9] and all-cause mortality [10-13]. Current guidance from the United Kingdom (UK) Department of Health and Social Care suggests that adults aged 18-64 years old should aim to engage in at least 150 minutes of moderate intensity activity (e.g. brisk walking or cycling) or 75 minutes of vigorous intensity activity (e.g. running) or shorter durations of very vigorous activities (e.g. sprinting or stair climbing) each week – or a combination of these intensity levels [14]. Nevertheless, recent data (2020-21) show that only between 61.4% [15] and 65.9% [16] of adults meet this threshold.[2]

Developments in wearable technologies enable individuals to measure and monitor their physical activity more accurately (e.g. using step counts) [17, 18] and have also been shown to be a motivational tool to encourage people to engage in physical activity, at least in the short term [19-22]. Incentives, including monetary rewards, are another way in which people can be encouraged to engage in desired behaviours, such as increased physical activity [23-25].

Vitality, a private insurance company in the UK, has offered to its members since 2016 the Vitality Active Rewards with Apple Watch (VARAW) benefit. This benefit uses both wearable technology and incentives to encourage health behaviour change, including physical activity. The VARAW benefit is a loss-framed monthly incentive alongside the Vitality Active Rewards gain-framed incentive programme.[3] The VARAW benefit gives eligible Vitality Active Rewards members the opportunity to purchase an Apple Watch for a small upfront deposit (c. 10% of retail price), plus monthly repayment amounts over 24 or 36 months that are linked to recorded physical activity levels and specific activity targets. In essence, increased physical activity and/or meeting physical activity targets results in lower repayments for the watch. Members can earn up to eight points per day and 40 points per week; as an indication of what level of activity is required to earn points, 7,000 steps in a day earns three points, 10,000 steps earns five points and 12,500 steps earns eight points.[4] An example of the financial contribution that may need to be made is provided in Table 1.

[2] Variations may be due to ages of adults differing (e.g. some use threshold of 16+ and others 18+) or be impacted by the date of survey and respective lockdown periods due to the Coronavirus pandemic. The range is, however, consistent with pre-pandemic figures.

[3] The Vitality Active Rewards programme provides members with cinema tickets or beverages, among other rewards, for reaching their personalised weekly activity target.

[4] For more information about the Vitality programme and its related incentives schemes to enhance physical activity levels, including Vitality Active Rewards and Vitality Active Rewards with Apple Watch, please consult Chapter 2 of reference [26].

Table 1: Financial contribution example for a Series SE Apple watch (1st watch).

Activity Points in previous month	0-39	40-79	80-119	120-159	160+
Vitality Contribution	£0.00	£2.50	£5.00	£7.50	£9.50
Member Contribution	£9.50	£7.00	£4.50	£2.00	£0.00

After the 24- or 36-month period, Vitality members are offered the opportunity to renew the VARAW benefit by purchasing a second watch (a newer model) albeit at a higher upfront cost (c. 50% of retail price), with the same loss-framed incentive structure for monthly repayments to cover the remaining amount over a 36-month period. This can then extend to a third and fourth benefit and so on.

In 2018, Vitality commissioned RAND Europe to evaluate the impact of the VARAW benefit compared with the Vitality Active Rewards programme alone in terms of physical activity outcomes [26]. While the study showed that the VARAW benefit was associated with improved physical levels over an average follow-up of approximately six months, at the time it was not possible to assess outcomes over a longer time period because the VARAW benefit was relatively new.

The aim of this longitudinal, observational study was to examine changes in physical activity over a longer timeframe to assess potential long-term behaviour change, and also to assess the relationship between VARAW benefit renewal and physical activity behaviours. Specifically, we aimed to address two main questions:

1) Does uptake of the VARAW benefit among Vitality members correspond to changes in physical activity levels relative to the Vitality Active Rewards programme alone, and are these effect sizes sustained after the benefit expires?
2) Among those who accessed the VARAW benefit, does the renewal of the benefit correspond to changes in physical activity levels relative to the first VARAW benefit?

We further sought to address a third, exploratory research question:

3) Among people who selected into subsequent VARAW benefits, does renewal of the benefit correspond to changes in physical activity levels relative to before the first benefit?

2. Data & Methods

2.1. Overview of data

For this analysis, Vitality provided data files on UK members of the Vitality Active Rewards programme who are eligible for the VARAW benefit from January 2016 to September 2022. The data contained information on member demographics (including age and gender), health information (including body mass index [BMI]) and monthly physical activity that was recorded by a wearable smart device. Physical activity days are calculated based on the following thresholds:

- **Low-level activity**: ≥7,000 to <10,000 steps.
- **Medium-level activity:** ≥10,000 to <12,500 steps, ≥30 to <60 minutes physical activity at 60% maximum heart rate, ≥30 to <60 minutes of physical activity at 300 kilocalories per hour, a gym workout, a park run or a digital at-home exercise class.
- **High-level activity:** ≥12,500 steps, ≥60 minutes of physical activity at 60% maximum heart rate; ≥30 minutes at 70% maximum heart rate, ≥30 minutes of physical activity at 600 kilocalories per hour, ≥60 minutes of physical activity at 300 kilocalories per hour or a gym workout/park run/digital at-home workout in conjunction with additional steps, heart rate or calorie activity.

This study included Vitality Active Rewards members who self-selected into the VARAW benefit and those who did not. Members who selected into the VARAW benefit may have renewed the benefit a second or third time. We excluded members for whom there was no information in the dataset about whether they selected into the VARAW benefit, if date of birth was missing or if date of birth corresponded to an age 100 years or greater. We also excluded members who had no observations for physical activity.

2.1.1. Outcome variables

The main outcome measurements were:

- The number of days of physical activity per month (low-, moderate- or high-level), defined by days for which a minimum threshold of physical activity was met as set by the Vitality Active Rewards programme (as described above).
- The number of high-level physical activity days per month as a proportion of days of total physical activity per month.

2.1.2. Primary analyses – explanatory variables

The primary analysis was focused on the relationship between the first VARAW benefit and physical activity. The main explanatory variable of interest was *VARAW benefit status*, coded as a categorical variable for each month over time per member (0= before uptake of the VARAW benefit or never received the benefit; 1= first VARAW benefit active; 2= first VARAW benefit expired).

Additional time-dependent explanatory variables of interest related to the uptake of the first VARAW benefit included the following:

- *Overall time*, which was coded as a continuous variable for each month from the first month of recorded physical activity to a censoring date. For the primary analysis, the censoring date was the last observation of physical activity or, specific to members who accessed the VARAW benefit and if applicable, the last observation before a second VARAW benefit was accessed.
- *Time during which the first VARAW benefit was active,* which was coded as a continuous variable for each month from the first month of receiving the benefit (e.g. 1, 2, 3, etc.). Observations for members before and after the first VARAW benefit period or observations for members who never received the benefit were set to '0'.
- *Time after which the first VARAW benefit expired,* which was coded as a continuous variable for each month from the first month after the benefit expired (e.g. 1, 2, 3, etc.). Observations for members before the expiration of the first VARAW benefit and after the start of a second VARAW benefit, or observations for members who never received the benefit were set to '0'.

Other explanatory variables were included to control for differences between members who accessed the VARAW benefit and those who did not (i.e. potential confounding variables). These include the following variables, which were coded categorically:

- *Baseline age*, coded as 18-34, 35-54, 55-64, 65+ years.
- *Gender*, coded as male, female and missing.
- *Baseline smoking status*, coded as never smoker, current smoker, former smoker and missing.
- *Baseline BMI*, coded as underweight (<18.5 kg/m^2), healthy (≥18.5 kg/m^2 to <25 kg/m^2) overweight (≥25 kg/m^2 and <30 kg/m^2), obese (≥30 kg/m^2) and missing (values <12 and >60 kg/m^2 were considered biologically implausible and were set to missing, alongside true missing values).
- *Calendar year*, coded as each year inclusive of 2016 and 2022.
- *Calendar month*, coded as each month from January to December, numerically from 1 to 12.

2.1.3. Secondary analyses – explanatory variables

The secondary analysis was focused on the relationship between subsequent VARAW benefits among members who accessed the first benefit and physical activity. The main explanatory variable of interest was *VARAW benefit status*, coded as a categorical variable for each month over time per member (0= first VARAW benefit active; 1= first VARAW benefit expired [and prior to renewal of the benefit, i.e. second

benefit]; 2= second VARAW benefit active; 3= second VARAW benefit expired [and prior to the renewal of the benefit, i.e. third benefit]; 4= third VARAW benefit active).

Additional time-dependent explanatory variables of interest related to the uptake of the VARAW benefit were included. These represented *overall time* from the start of the first VARAW benefit to the censoring date, time on and after the expiry of the second VARAW benefit and, lastly, time on the third VARAW benefit. Observations were censored at the last observation of physical activity or the last observation of the third VARAW benefit.[5]

Other explanatory variables include the potential confounders described above (see **Section 2.1.2**).

2.1.4. Missing data and sensitivity analyses

Physical activity data may have been missing because members were not wearing/using their smart device. Because physical activity data are unlikely to be missing at random, biases may be introduced when analysing only complete data. To account for missingness of the outcome, we conducted two sensitivity analyses, one in which missing physical activity data were imputed to '0' (assuming that no physical activity occurred) and a second in which missing physical activity data were imputed to the maximum number of days in a given month (e.g. missing activity in February was set to 28). We then compared study outcomes among the non-missing cohort to these two imputed cohorts to determine if outcomes were robust to missingness.

When data were missing for confounding variables, we included a level for 'unknown/missing' for each categorical variable, as described earlier.

2.2. Data analysis

Two statistical software packages were used for this analysis. Data management, cleaning and descriptive statistics were performed in R, while inferential statistical models were conducted in STATA 17.0.

2.2.1. Descriptive statistics

Continuous variables were summarised as means with standard deviations (SDs). Categorical variables were summarised as percentages.

We also descriptively examined linear trends in the number of physical activity days and the proportion of high-level physical activity days by VARAW benefit status. Among those who accessed the VARAW benefit, time was stratified into periods before, during and after each VARAW period (first, second, third). Because there were few observations after the third VARAW benefit, we excluded these from our analysis. For comparative purposes, data for the primary analyses were structured so that observations for members before they accessed the first VARAW benefit and observations for members who never accessed the benefit begin at time '0', and the beginning of each subsequent period was aligned sequentially. Similarly, for the secondary analyses, data were structured so that observations for the first VARAW benefit begin at time '0'

[5] There were few observations for members after the expiry of the third VARAW benefit. These observations were excluded from our analysis.

and the beginning of each subsequent period was aligned sequentially. Linear trends are reported with 95% confidence intervals (CIs).

2.2.2. Inferential statistics

Primary analyses

Our primary analyses were designed to address the following research question:

- *Does uptake of the VARAW benefit among Vitality members correspond to changes in physical activity levels relative to the Vitality Active Rewards programme alone, and are these effect sizes sustained after the benefit expires?*

To this end, we used an interrupted time-series analysis approach to examine the relationships between receiving a first VARAW benefit and the number of physical activity days (non-negative integer counts ranging from 0 to 31) and the proportion of high-level physical activity days per month (values ranging from 0 to 1). For these analyses, observations were censored at the start date for initiating a second benefit (if applicable), otherwise all observations were administratively censored at the last month of recorded physical activity. All models included clustered robust variance-covariance estimation by member to avoid spurious statistical associations, given multiple non-independent observations for each member in the dataset.

For the number of physical activity days, as a count variable, we used a negative binomial regression model to model the association between VARAW benefit status and number of physical activity days per month with statistical adjustment for potential confounding variables. All fixed-effect model coefficients and 95% CI were exponentiated to the normal scale and, thus, are interpreted as incident rate ratios (IRRs). Because our two main outcomes are correlated, we used a Bonferroni correction for statistical significance (0.05/2). Thus, we considered a p-value <0.025 to be statistically significant.

For the outcome of proportion of high-level physical activity days, because this variable was not normally distributed and did not meet assumptions for a linear model, we recoded values ranging from 0 to 1 as a seven-level categorical variable: 0; >0 to <0.2; ≥0.2 to <0.4; ≥0.4 to <0.6; ≥0.6 to <0.8; ≥0.8 to <1; 1. We used an ordered logit model, with 0 as the reference category, to model the relationship between VARAW benefit status and the odds of proportionally increasing days of physical activity per month with statistical adjustment for potential confounding variables. All fixed-effect model coefficients and 95% CI were transformed to the normal scale and thus represent odds ratios (ORs). A p-value <0.025 was considered statistically significant.

For both outcomes, postestimation was used to compare point estimates across different levels of the VARAW benefit status variable. For example, we examined incidence rates or odds for the post-VARAW benefit period relative to the VARAW benefit period. We repeated the primary analyses with stratification by baseline BMI categories because we believed it was possible that a member's BMI may be related to motivation to engage in physical activity and thus how they engage with the VARAW benefit.

Secondary analyses

Our secondary analyses were designed to address the following research question:

- *Among those who accessed the VARAW benefit, does renewal of the benefit correspond to changes in physical activity levels relative to the first VARAW benefit?*

To this end, we used an interrupted time-series analysis approach to examine the relationship between renewal of the benefit (i.e. receiving a second or third Apple Watch) and physical activity over time among Vitality members who received a first VARAW benefit. Similar to the primary analyses, we examined two outcomes: number of physical activity days per month, and proportion of high-level physical activity days per month. Secondary analyses were conducted as described above for the primary analyses. Members who received the VARAW benefit were censored at the end of the third watch period, otherwise all observations were administratively censored at the last month of recorded physical activity in the dataset. All estimates were reported with 95% CI. A p-value <0.025 was considered statistically significant.

For both outcomes, postestimation was used to compare point estimates across different levels of the VARAW benefit status variable. For example, we examined incidence rates or odds for the second VARAW benefit period relative to the post-initial VARAW benefit period.

Exploratory analyses

Due to issues of self-selection into VARAW benefits and likely differences between members who selected into only the first benefit compared with those who selected into a second or third benefit, we conducted additional exploratory analyses. Our exploratory analyses were designed to address the following research question:

- *Among people who selected into subsequent VARAW benefits, does renewal of the benefit correspond to changes in physical activity levels relative to before the first benefit?*

Specifically, we conducted sub-analyses among members who had at least two benefits, examining relationships between physical activity days and the proportion of high-level physical activity days for the first, post-first and second VARAW benefit periods relative to the pre-first VARAW benefit period. Similarly, among members who had at least three benefits, we examined the relationship between outcomes and the first, post-first, second, post-second and third VARAW benefit period compared with the pre-first VARAW benefit period. All analyses were conducted as described above.

3. Results

3.1. Overview of cohort

3.1.1. Descriptive summary of cohort

Overall, 954,679 unique Vitality Activity Reward programme members were available for analysis. After excluding members who did not meet eligibility criteria, 660,212 Vitality members (69.5%) were retained with a total of 13,350,828 monthly observations of physical activity between January 2016 and September 2022 (see Annex A, Figure A.1, for flow chart). Among included members, 172,301 (26.1%) accessed the VARAW benefit and 487,911 (73.9%) did not.

On average, members who accessed the VARAW benefit had approximately 28 episodes of recorded monthly activity data over 33 calendar months (median = 24 episodes over 30 months), whereas members who did not access the VARAW benefit had approximately 17 episodes over 21 calendar months (median = 11 episodes over 13 months) (see Table 2). Each member had a minimum of 1 observation and a maximum of 81.

Table 2: Number and duration of observations per user by VARAW benefit status.

	All Members, N = 660,212	Accessed VARAW Benefit N = 172,301	Never Accessed VARAW Benefit N = 487,911
Number of observations per member *			
Mean (SD)	20.2 (19.3)	28.5 (20.6)	17.3 (17.8)
Median (IQL)	13.0 (5.0-30.0)	24.0 (11.0-42.0)	11.0 (4.0-24.0)
Calendar months from first to last observation per member *			
Mean (SD)	24.0 (22.2)	32.8 (22.6)	20.9 (21.3)
Median (IQL)	17.0 (6.0-38.0)	30.0 (13.0-49.0)	13.0 (4.0-32.0)
Missing observations (number of months between first and last observation without activity measurement) *			
Mean (SD)	4.8 (9.4)	5.3 (9.6)	4.6 (9.3)
Median (IQL)	0 (0-5.0)	1.0 (0-6.0)	0 (0-5.0)
Percent missing *			
Mean (SD)	14.1 (21.7)	13.2 (20.2)	14.4 (22.2)
Median (IQL)	0 (0-22.2)	1.4 (0-20.0)	0 (0-23.1)

*Notes: IQL, interquartile limit; SD, standard deviation; VARAW, Vitality Active Rewards with Apple Watch. Percentage of missing values based on calendar months. * P-value < 0.001 based on Welch two-sample t-test for the comparison of means for the group that accessed VARAW benefit versus the group that did not.*

Vitality Active Rewards programme members were on average 37 years of age; mean age was similar for members who accessed the VARAW benefit and those who did not. Among members where baseline characteristics were available, 46.3% were female, 72.5% never smoked and approximately half (49.4%) had a BMI in the healthy range (Table 3). Members who accessed the VARAW benefit compared with those who did not were more frequently male (56.6% versus 52.7%; P<0.001) and had a BMI in the overweight range (38.3% versus 34.4%: P<0.001).

Table 3: Baseline characteristics by VARAW benefit status.

		All Members N = 660,212	Accessed VARAW Benefit N = 172,301	Never Accessed VARAW Benefit N = 487,911
Mean Age (SD)		36.87 (10.3)	36.16 (9.3)	37.12 (10.6)
Gender, n (%) *	Male	354,388 (53.7%)	97,462 (56.6%)	256,926 (52.7%)
	Female	305,820 (46.3%)	74,838 (43.4%)	230,982 (47.3%)
	Missing	4	1	3
Baseline smoking status, n (%) *	Never smoker	78,188 (72.5%)	23,868 (72.7%)	54,320 (72.4%)
	Used to smoke	22,043 (20.4%)	6,747 (20.6%)	15,296 (20.4%)
	Current smoker	7,643 (7.1%)	2,198 (6.7%)	5,445 (7.3%)
	Missing	552,338	139,488	412,850
Baseline BMI category, n (%) *	Healthy	53,202 (49.4%)	15,533 (47.4%)	37,669 (50.3%)
	Underweight	1,457 (1.4%)	285 (0.9%)	1,172 (1.6%)
	Overweight	38,308 (35.6%)	12,541 (38.3%)	25,767 (34.4%)
	Obese	14,691 (13.6%)	4,403 (13.4%)	10,288 (13.7%)
	Missing	552,554	139,539	413,015

*Notes: BMI, body-mass index; SD, standard deviation; VARAW, Vitality Active Rewards with Apple Watch. * P-value < 0.001 for Pearson's Chi-squared test comparing the group that accessed the VARAW benefit versus the group that did not.*

3.1. Primary analyses: relationship between physical activity and first VARAW benefit status

3.1.1. Descriptive summary of primary analyses

Among 172,301 members who accessed the VARAW benefit, the average number of physical activity days per month before accessing the benefit was 15.9 (SD=9.0), and among 487,911 members who never accessed the benefit the average number of physical activity days per month was 14.7 (SD=9.0). The proportion of high-level physical activity days per month was similar for these groups (mean = 0.36 [SD=0.28] prior to accessing the benefit compared with 0.34 [SD=0.30] for those who never accessed the benefit; see Table 4).

While the first VARAW benefit was active, the average number of physically active days per month increased to 19.9 (SD=8.6) and the proportion of high-level physical activity days per month increased to 0.42 (SD=0.25). After the first VARAW benefit expired, the average number of physical activity days decreased slightly to 18.4 (SD=9.0), and the proportion of high-level physical activity days per month stayed approximately the same at 0.41 (SD=0.26) (Table 4).

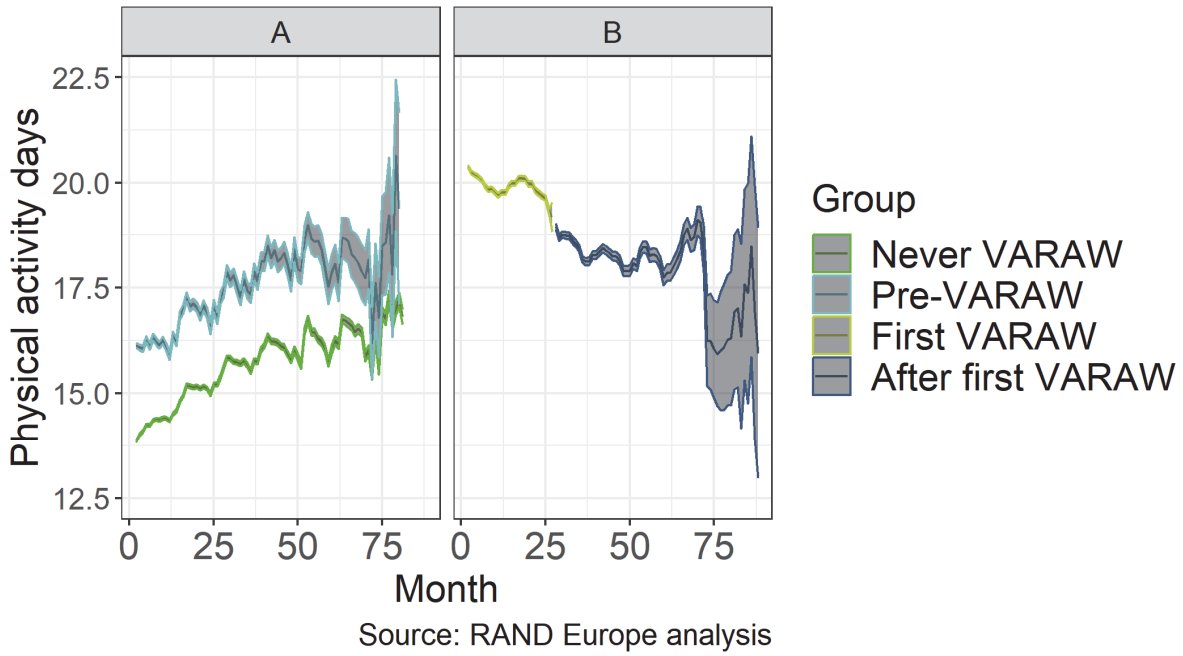
Table 4: Physical activity days per month and proportion of high activity days per month by VARAW benefit status.

	Never Received VARAW Benefit	Before VARAW Benefit	During VARAW Benefit	After VARAW Benefit
Mean physical activity days (SD)	14.7 (9.1)	15.9 (9.0)	19.9 (8.6)	18.4 (9.0)
Mean proportion of high-level physical activity days (SD)	0.34 (0.30)	0.36 (0.28)	0.42 (0.25)	0.41 (0.26)
Mean calendar months (SD)	17.3 (17.8)	8.0 (11.4)	15.7 (8.8)	14.2 (11.3)
Median calendar months (IQL)	11.0 (4.0-24.0)	2.0 (1.0-11.0)	16.0 (8.0-25.0)	11.0 (5.0-21.0)

Notes: IQL, interquartile limit; SD, standard deviation; VARAW, Vitality Active Rewards with Apple Watch.

Figure 3:1 shows the mean number of physical activity days per month over time by VARAW benefit status and period. Overall, there was in increasing trend in number of physical activity days for Vitality Active Rewards members prior to accessing the VARAW benefit and among members who never received the benefit (Figure 3:1, Panel A). Notably, those who ultimately accessed the benefit appeared to have higher levels of physical activity over time, which may reflect that this is a more motivated or a more healthy-behaviour oriented group. The period of time marking the initiation of the first VARAW benefit was associated with an increase in physical activity, after which physical activity decreased over time through the post-VARAW benefit period (Figure 3:1, Panel B). Overall, however, the unadjusted mean number of physical activity days, both during the VARAW benefit period and after its expiry, were greater than those observed both in the pre-VARAW period and among those who never received it.

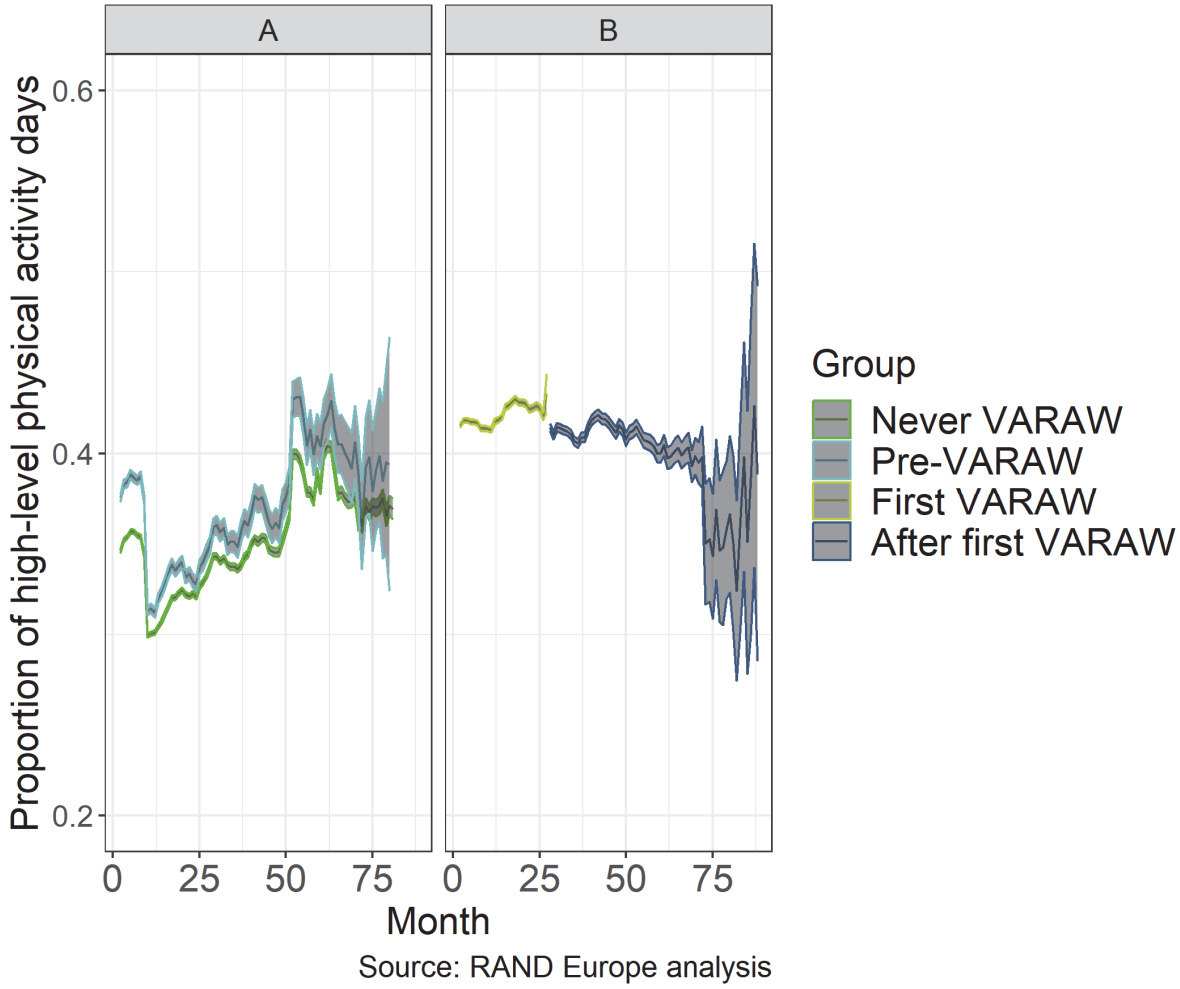
Figure 3:1: Mean number of physical activity days per month over time by VARAW benefit status.



Notes: VARAW, Vitality Active Rewards with Apple Watch. Mean trends shown with 95% CI. For comparative purposes, data were structured so that observations for members before they accessed the first VARAW benefit and observations for members who never accessed the benefit begin at 0, and the beginning of each subsequent period was aligned sequentially. CI widen as individuals move from one period to the next (e.g. there are fewer people who were still in the pre-VARAW period at 30 months compared with 20 months since some of these individuals entered the VARAW period).

Figure 3:2 shows the mean proportion of high-level physical activity days per month over time by VARAW benefit status and period. Trends are similar to those for the number of physical activity days; however, the proportion of high-level physical activity appears to be sustained during the VARAW benefit period, and gradually declines in the post-VARAW benefit period. The observed unadjusted mean proportion of high-level physical activity days during the first VARAW benefit period and after its expiry was greater overall than those observed both in the pre-VARAW period and among those who never received it.

Figure 3:2: Mean proportion of high-level physical activity days per month over time by VARAW benefit status.



Notes: VARAW, Vitality Active Rewards with Apple Watch. Mean trends shown with 95% CI. For comparative purposes, data were structured so that observations for members before they accessed the first VARAW benefit and observations for members who never accessed the benefit begin at 0, and the beginning of each subsequent period was aligned sequentially. CI widen as individuals move from one period to the next (e.g. there are fewer people that were still in the pre-VARAW period at 30 months compared with 20 months since some of these individuals entered the VARAW period).

3.1.2. Inferential statistics for primary analyses

In this section, we present detailed findings from the primary analyses. Key findings are shown in Box 1 below.

Box 1. Key findings from primary analyses.

Research Question: *Does uptake of the VARAW benefit among Vitality members correspond to changes in physical activity levels relative to the Vitality Active Rewards programme alone, and are these effect sizes sustained after the benefit expires?*

- The first VARAW benefit period was associated with increases in the number of physical activity days per month, as well as the proportion of high-level physical activity days, compared with the period before the first VARAW benefit and to members who never accessed the benefit.
- The relationship between increases in physical activity were sustained after the first VARAW benefit expired, albeit to a slightly lesser degree compared with when the first benefit was active.

Number of physical activity days

After adjusting for member demographics and characteristics, time trends and calendar time, the first VARAW benefit period was associated with a statistically significant increase in the number of physical activity days per month compared with both the pre-VARAW benefit period or never accessing the VARAW benefit (IRR: 1.405; 95% CI: 1.410, 1.408; P<0.001) (Table 5). The post-VARAW benefit period was also associated with a statistically significant increase in physical activity days compared with both the pre-VARAW benefit period or never accessing the benefit (IRR: 1.196; 95% CI: 1.191, 1.201; P<0.001); however, this represented a decrease relative to the period in which the VARAW benefit was active (postestimation = IRR: 0.851; 95% CI: 0.848, 0.855; P<0.001). While overall monthly time trends were positively associated with physical activity levels, monthly time trends during the VARAW benefit period and the post-VARAW period were negatively associated with physical activity levels, representing a gradual decline in physical activity of about 0.4% per month (IRR: 0.996, 95% CI: 0.996, 0.996; P<0.001). Independent of VARAW benefit status and time, higher incidence rates of physical activity days were observed among older members, males, those whose BMI was in the healthy range and never smokers.

Table 5: Negative binomial regression modelling output for the number of physical activity days per month.

	Incident Rate Ratios (95% Confidence Intervals)	
	Model Output	Post estimation
VARAW Status		
Never/Before first VARAW	Ref	0.712 (0.710, 0.714) *
During first VARAW	1.405 (1.401, 1.408) *	Ref
After first VARAW	1.196 (1.191, 1.201) *	0.851 (0.848, 0.855) *
Overall time in months	1.003 (1.003, 1.003) *	–
VARAW time in months	0.996 (0.996, 0 .996) *	–
After VARAW time in months	0.996 (0.996, 0 .996) *	–
Age in Years		
18 – 34	Ref	–
35 – 54	1.113 (1.110, 1.116) *	–
55 – 64	1.118 (1.110, 1.126) *	–
65+	1.162 (1.146, 1.178) *	–
Gender		
Male	Ref	–
Female	0.982 (0.980, 0.985) *	–
Missing	0.985 (0.546, 1.777)	–
Baseline Body-Mass Index		
Healthy	Ref	–
Overweight	0.964 (0.958, 0.970) *	–
Obese	0.868 (0.859, 0.876) *	–
Underweight	0.919 (0.884, 0.944) *	–
Missing	0.978 (0.930, 1.029)	–
Baseline Smoking Status		
Never Smoker	Ref	–
Current Smoker	0.898 (0.867, 0.909) *	–
Former Smoker	0.981 (0.974, 0.988) *	–
Missing	1.009 (0.959, 1.061)	–
Calendar Year	1.008 (1.008, 1.009) *	–
Calendar Month	0.999 (0.998, 0.999) *	–

Notes: *VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed.* *P<0.001.

IRRs for the number of physical activity days during the first VARAW benefit period compared with before or never accessing the benefit were largely similar across baseline BMI categories (Table 6); however, based on

non-overlapping 95% CI, physical activity appeared to be sustained at a higher level during the post-VARAW benefit among members categorised as underweight relative to members in the other BMI categories.

Table 6: Negative binomial regression modelling output for the number of physical activity days per month by baseline BMI categories.

	Incident Rate Ratios (95% Confidence Intervals)			
	Underweight	Healthy Weight	Overweight	Obese
VARAW Status				
Never/Before first VARAW	Ref	Ref	Ref	Ref
During first VARAW	1.442 (1.361, 1.527) **	1.383 (1.372, 1.393) **	1.361 (1.349, 1.374) **	1.360 (1.336, 1.384) **
After first VARAW	1.362 (1.242, 1.494) **	1.221 (1.206, 1.236) **	1.192 (1.75, 1.210) **	1.204 (1.169, 1.240) **
Overall time in months	1.002 (1.000, 1.003)	1.002 (1.002, 1.002) **	1.003 (1.002, 1.003) **	1.004 (1.003, 1.004) **
VARAW time in months	1.002 (0.999, 1.006)	0.998 (0.997, 0.999) **	0.998 (0.997, 0.998) **	0.999 (0.997, 0.999) *
After VARAW time in months	0.997 (0.992, 1.001)	0.997 (0.996, 0.997) **	0.997 (0.996, 0.998) **	0.996 (0.994, 0.997) **

*Notes: BMI, body-mass index; VARAW, Vitality Active Rewards with Apple Watch. *P<0.01; **P<0.001.*

Proportion of high-level physical activity days

After adjusting for member demographics and characteristics, time trends and calendar time, the first VARAW benefit period was associated with a statistically significant increase in the proportion of high-level physical activity days per month compared with both the pre-VARAW benefit period and never accessing the VARAW benefit (OR: 1.637; 95% CI: 1.620, 1.654; P<0.001) (Table 7). Overall time trends and time trends during the first VARAW benefit period were positively associated with a higher proportion of high-level physical activity days, whereas the monthly time trends for the post-VARAW period were negatively associated with high-level physical activity levels, suggesting slight declines in high-level physical activity after the first VARAW benefit expired; these trends represent changes of about 0.2% to 0.8% in the odds of more high-level physical activity days per month. Overall, however, the post-VARAW benefit period was also associated with a statistically significant increase in the proportion of high-level physical activity days compared with both the pre-VARAW benefit period and never accessing the benefit (OR: 1.634; 95% CI: 1.602, 1.667; P<0.001).

Independent of VARAW benefit status and time, older members, males, those whose BMI was in the healthy range and never smokers were more likely to have a higher proportion of high-level physical activity days.

Table 7: Ordered logit regression modelling output for the proportion of high-level physical activity days per month.

	Odds Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
Never/Before first VARAW	Ref	0.590 (0.586, 0.594) *
During first VARAW	1.637 (1.620, 1.654) *	Ref
After first VARAW	1.634 (1.602, 1.667) *	0.919 (0.907, 0.9310 *
Overall time in months	1.002 (1.002,1.002) *	–
VARAW time in months	1.002 (1.002, 1.002) *	–
After VARAW time in months	0.992 (0.991, 0.992) *	–
Age in Years		
18 – 34	Ref	–
35 – 54	1.354 (1.344, 1.365) *	–
55 – 64	1.471 (1.437, 1.506) *	–
65+	0.981 (0.932, 1.032)	–
Gender		
Male	Ref	–
Female	0.803 (0.797, 0.810) *	–
Missing	0.961 (0.654, 1.410)	–
Baseline Body-Mass Index		
Healthy	Ref	–
Overweight	0.908 (0.894, 0.923) *	–
Obese	0.703 (0.688, 0.720) *	–
Underweight	0.783 (0.733, 0.836) *	–
Missing	0.899 (0.763, 1.060)	–
Baseline Smoking Status		
Never Smoker	Ref	–
Current Smoker	0.741 (0.720, 0.762) *	–
Former Smoker	0.946 (0.929, 0.963) *	–
Missing	1.020 (0.865, 1.202)	–
Calendar Year	1.029 (1.027, 1.031) *	–
Calendar Month	0.985 (0.985, 0.985) *	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed. *P<0.001.*

ORs for a proportion of high-level physical activity days during the first VARAW benefit period, compared with before or never accessing the benefit, were larger for members whose BMI was in the range of healthy,

overweight or obese relative to those whose BMI was in the range of underweight (based on ORs and non-overlapping 95% CI) (Table 8); however, and also based on ORs and non-overlapping 95% CIs, high-level physical activity levels did not appear to differ by BMI category after the first VARAW benefit period.

Table 8: Ordered logit regression modelling output for the proportion of high-level physical activity days per month by baseline BMI category.

	Odds Ratios (95% Confidence Intervals)			
	Underweight	Healthy Weight	Overweight	Obese
VARAW Status				
Never/Before first VARAW	Ref	Ref	Ref	Ref
During first VARAW	1.400 (1.310, 1.495) **	1.922 (1.876, 1.969) **	1.838 (1.786, 1.891) **	1.874 (1.787, 1.966) **
After first VARAW	1.370 (1.198, 1.565) **	1.595 (1.532,1.660) **	1.516 (1.449, 1.587) **	1.629 (1.499, 1.770) **
Overall time in months	1.002 (1.000, 1.003)	1.003 (1.002, 1.003) **	1.003 (1.002, 1.004) **	1.007 (1.005, 1.008) **
VARAW time in months	1.002 (0.999, 1.004)	0.997 (0.995, 0.998) **	0.998 (0.997, 0.999) *	0.997 (0.994, 1.000)
After VARAW time in months	0.994 (0.989, 0.998) *	0.992 (0.990, 0.994) **	0.993 (0.991, 0.995) **	0.986 (0.981, 0.990) **

*Notes: BMI, body-mass index; VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI were adjusted for time during each period, calendar time and month and gender, as well as baseline age, body-mass index and smoking status. *P<0.01: **P<0.001.*

3.2. Secondary analyses: relationship between physical activity and renewal of the VARAW benefit

3.2.1. Descriptive summary of the secondary analyses

Among 168,968 members who selected into the first VARAW benefit (total observations=3,927,472), 15,165 renewed the benefit (second VARAW benefit) and 894 renewed the VARAW benefit for the third time. As mentioned for the primary analyses, there was an increase in the number of physical activity days after the start of the first VARAW benefit compared with the period before, with a slight decline in physical activity days in the period after the first VARAW benefit expired. These measures of physical activity showed similar trends for the second and third VARAW benefit (i.e. increases in physical activity), with a slight dip in physical activity in the intermediary period between the second and third benefit (Table 9).

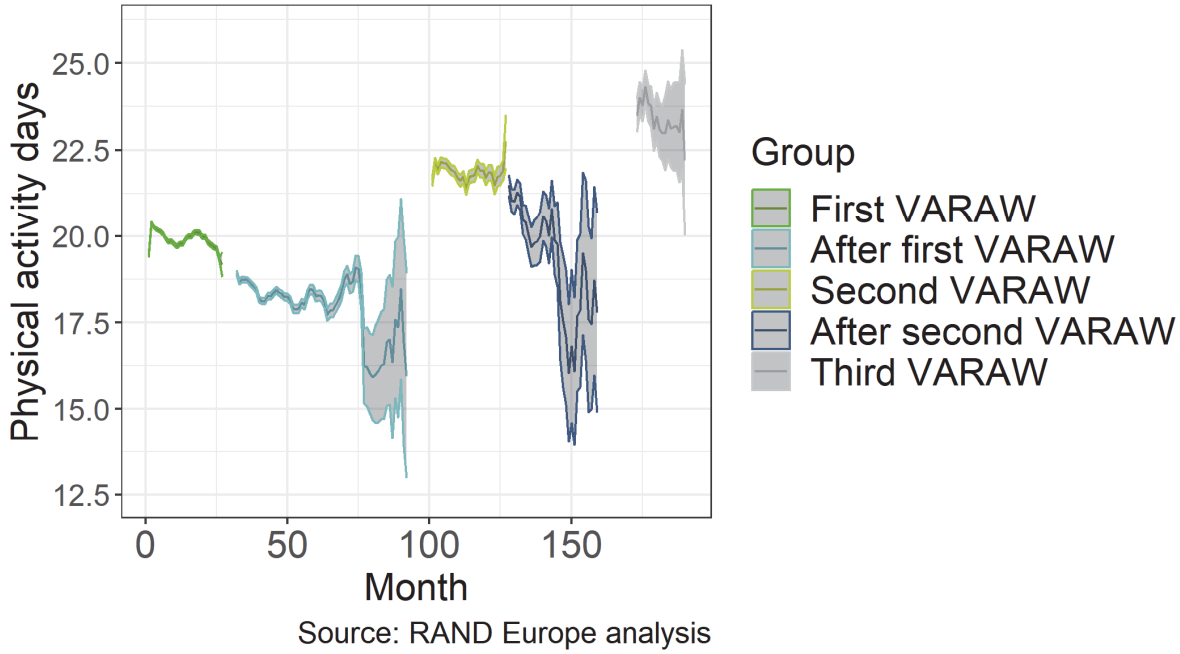
Table 9: Mean physical activity days per month and mean proportion of high-level physical activity days per month by first, second and third VARAW benefit status.

	First VARAW Benefit	After First VARAW Benefit	Second VARAW Benefit	After Second VARAW Benefit	Third VARAW Benefit
Mean physical activity days (SD)	19.9 (8.6)	18.4 (9.0)	21.9 (8.0)	20.6 (8.5)	23.6 (7.1)
Mean proportion of high activity days (SD)	0.42 (0.25)	0.41 (0.26)	0.48 (0.24)	0.45 (0.24)	0.51 (0.22)
Mean calendar months (SD)	15.7 (8.8)	14.2 (11.3)	14.3 (8.1)	6.4 (5.7)	8.1 (5.1)
Median calendar months (IQL)	16.0 (8.0-25.0)	11.0 (5.0-21.0)	14.0 (7.0-22.0)	5.0 (2.0-8.0)	7.0 (4.0-10.0)

Notes: IQL, interquartile limit; SD, standard deviation; VARAW, Vitality Active Rewards with Apple Watch.

Figure 3:3 shows mean trends over time for the number of physical activity days, starting from the first VARAW benefit through to the end of the third VARAW benefit. Overall, second and third VARAW benefits are associated with an increase in physical activity relative to the first VARAW benefit and the period during which the first benefit had expired.

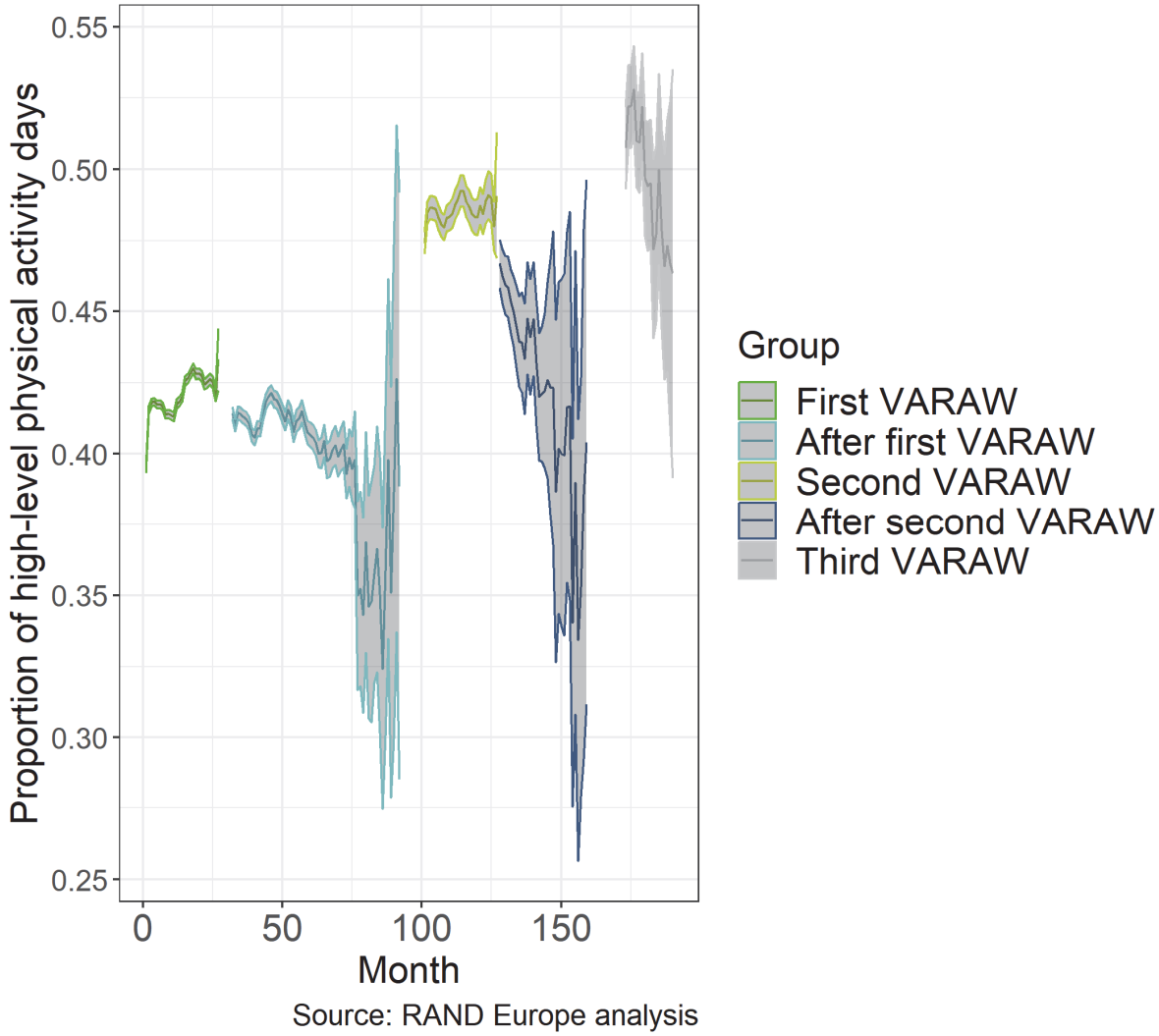
Figure 3:3: Mean physically active days per month among members who accessed VARAW benefit by VARAW benefit period.



Notes: VARAW=Vitality Active Rewards with Apple Watch. Mean trends shown with 95% CI. For comparative purposes, data were structured so that observations for the first VARAW benefit begin at 0 and the beginning of each subsequent period was aligned sequentially. CI widen as individuals move from one period to the next (e.g. from the period after the first VARAW benefit to the second VARAW benefit).

Figure 3:4 shows mean trends over time for the proportion of high-level physical activity days, starting from the first VARAW benefit through to the end of the third VARAW benefit. Overall, second and third VARAW benefits were associated with an increase in the proportion of high-level physical activity days relative to the first VARAW benefit and the period during which the first VARAW benefit had expired.

Figure 3:4: Mean proportion of high-level activity days per month among those who accessed VARAW benefit by VARAW benefit period.



Notes: VARAW=Vitality Active Rewards with Apple Watch. Mean trends shown with 95% CI. For comparative purposes, data were structured so that observations for the first VARAW benefit begin at 0 and the beginning of each subsequent period was aligned sequentially. CI widen as individuals move from one period to the next (e.g. from the period after the first VARAW benefit to the second VARAW benefit).

3.2.2. Inferential statistics for the secondary analyses

In this section, we present detailed findings from the secondary analyses. Key findings are shown in Box 2 below.

Box 2. Key findings from secondary analyses.

Research Question: *Among those who accessed the VARAW benefit, does renewal of the benefit correspond to changes in physical activity levels relative to the first VARAW benefit?*

- In the periods following the first VARAW benefit, the number of physical activity days per month were lower compared with when the first VARAW benefit was active; however, second and third benefits were associated with increases in the number of physical activity days per month relative to the immediate periods before, in which the first and second benefits, respectively, had expired.
- The second and third VARAW benefit periods were associated with increases in the proportion of high-level physical activity days per month relative to both the first VARAW benefit period and the immediate periods before, in which the first and second benefits, respectively, had expired.

Number of physical activity days

After adjusting for member demographics and characteristics, time trends and calendar time, the second VARAW benefit period was associated with a statistically significant increase in the incidence of physical activity days per month compared with post-first VARAW period (postestimation = IRR: 1.131; 95% CI: 1.122, 1.140; P<0.001); however, this represented a small drop in physical activity levels relative to the first VARAW benefit period (IRR: 0.952; 95% CI: 0.935, 0.970; P<0.001) (Table 10). The period after the second VARAW benefit expired was associated with a decrease in physical activity levels relative to the second benefit period (postestimation = IRR: 0.903; 95% CI: 0.884, 0.921; P<0.001 [not shown in table]). Physical activity levels increased again during the third VARAW benefit period compared with the post-second VARAW benefit period (post estimation = IRR: 1.113; 95% CI: 1.085, 1.141; P<0.001); however, this still represented a small, but statistically significant, reduction in physical activity relative to the first VARAW benefit period (IRR: 0.957; 95% CI: 0.924, 0.991; P<0.001) (Table 10).

While overall time trends were positively associated with physical activity levels, time trends for periods during which the VARAW was active and the post-VARAW periods were negatively associated with physical activity levels; these trends represent changes of about 0.3% to 0.4% in physical activity per month.

Table 10: Negative binomial regression modelling output for the number of physical activity days per month.

	Incident Rate Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
First VARAW benefit	Ref	[[omitted]]
Post-first VARAW benefit	0.842 (0.831, 0.852) **	Ref
Second VARAW benefit	0.952 (0.935, 0.970) **	1.131 (1.122, 1.140) **
Post-second VARAW benefit	0.860 (0.832, 0 .888) **	Ref
Third VARAW benefit	0.957 (0.924, 0.991) *	1.113 (1.085, 1.141) **
Overall time (in months)	1.004 (1.003, 1.004) **	–
First benefit time (in months)	0.996 (0.995, 0.996) **	–
Post-first benefit time (in months)	0.996 (0.995, 0.996) **	–
Second benefit time (in months)	0.997 (0.996, 0.997) **	–
Post-second benefit time (in months)	0.994 (0.992, 0.997) **	–
Third benefit time (in months	0.996 (0.992, 0 .999) *	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed and calendar month and year and gender, as well as baseline age, body-mass index and smoking status. *P<0.01; **P<0.001.*

Proportion of high-level physical activity days

After adjusting for member demographics and characteristics, time trends and calendar time, the second VARAW benefit period was associated with a statistically significant increase in the odds of a higher proportion of high-level physical activity days per month compared with the post-first VARAW period (postestimation = OR: 1.402; 95% CI: 1.356, 1.449; P<0.001) and an increase relative to the first VARAW benefit period (OR: 1.151; 95% CI: 1.072, 1.236; P<0.001) (Table 11). The period after the second VARAW benefit was associated with a decrease in odds of a higher proportion of high-level physical activity days relative to the second benefit period (postestimation = OR: 0.759; 95% CI: 0.696, 0.828; P<0.001 [not shown in table]). The proportion of high-level physical activity days increased again during the third VARAW benefit period compared with the post-second VARAW benefit period (postestimation = OR: 1.457; 95% CI: 1.293, 1.641; P<0.001 [not shown in table]) and the first VARAW benefit period (OR: 1.273; 95% CI: 1.095, 1.480; P<0.001) (Table 11).

Overall time trends were positively associated with a higher proportion of high-level physical activity days, whereas the time trends for all VARAW benefit periods and post-benefit periods were negatively associated with high-level physical activity levels, suggesting graduate declines in high-level physical activity from the first benefit; these trends represent changes of about 0.3% to 2.7% in the odds of a higher proportion of high-level activity per month.

Table 11: Ordered logit regression modelling output for the proportion of days of high-level physical activity per month.

	Odds Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
First VARAW benefit	Ref	[[omitted]]
Post-first VARAW benefit	0.821 (0.782, 0.862) **	Ref
Second VARAW benefit	1.151 (1.072, 1.236) **	1.402 (1.356, 1.449) **
Post-second VARAW benefit	0.874 (0.769, 0.993)	Ref
Third VARAW benefit	1.273 (1.095, 1.480) *	1.457 (1.293, 1.641) **
Overall time (in months)	1.005 (1.003, 1.007) **	–
First benefit time (in months)	0.997 (0.995, 0.999) *	–
Post-first benefit time (in months)	0.990 (0.998, 0.992) **	–
Second benefit time (in months)	0.995 (0.993, 0.997) **	–
Post-second benefit time (in months)	0.983 (0.972, 0.993) *	–
Third benefit time (in months)	0.973 (0.958, 0.988) *	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed and calendar month and year and gender, as well as baseline age, body-mass index and smoking status. *P<0.01; **P<0.001.*

3.3. Exploratory sub-analyses

In this section, we present detailed findings from the exploratory sub-analyses. Key findings are shown in Box 3 below.

Box 3. Key findings from exploratory sub-analyses.

Research Question: *Among people who selected into subsequent VARAW benefits, does renewal of the benefit correspond to changes in physical activity levels relative to before the first benefit?*

- Among members who selected into a second VARAW benefit, the number of physical activity days and proportion of high-level physical activity days per month increased during the first benefit period relative to the period before; these levels of physical activity were sustained through the second benefit period.
- Among a limited number of members who selected into a third VARAW benefit, the number of physical activity days per month increased during the first benefit period relative to the period before, which was sustained through the second benefit period but not after.

Among a subset of members who renewed the VARAW benefit for at least a second time (n=15,165), findings were consistent from previous analyses, such that the first VARAW benefit period was associated with an average increase in physical activity days relative to the period before the first benefit. Physical

activity levels were sustained in the period after the first benefit and during the second benefit period, albeit to a lesser degree (Table 12). Overall trends in physical activity increased monthly over time; however, within each period there was a decline in physical activity days per month.

The odds of a higher proportion of high-level physical activity days also increased in the first VARAW benefit period compared with the period before the first VARAW benefit and remained elevated in the period after the first benefit expired and during the second benefit period (Table 13).

Table 12: Negative binomial regression modelling output for the number of physical activity days per month among members who selected into at least two VARAW benefits.

	Incident Rate Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
Before first VARAW	Ref	0.827 (0.813, 0.841) *
During first VARAW	1.331 (1.320, 1.346) *	1.103 (1.089, 1.117) *
After first VARAW	1.209 (1.188, 1.230) *	Ref
Second VARAW	1.234 (1.209, 1.260) *	1.021 (1.012, 1.030) *
Overall time in months	1.001 (1.001, 1.0020 *	–
First VARAW in months	0.998 (0.997, 0.998) *	–
After VARAW time in months	0.995 (0.994, 0 .999) *	–
Second VARAW time in months	0.998 (0.998, 0.999) *	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed and calendar month and year and gender, as well as baseline age, body-mass index and smoking status. *P<0.001.*

Table 13: Ordered logit regression modelling output for the proportion of days of high-level physical activity per month among members who selected into at least two VARAW benefits.

	Odds Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
Before first VARAW	Ref	0.686 (0.635, 0.741) *
During first VARAW	1.384 (1.333, 1.436) **	0.949 (0.893, 1.009)
After first VARAW	1.458 (1.350, 1.575) **	Ref
Second VARAW	1.776 (1.620, 1.947) **	1.218 (1.171, 1.267) *
Overall time in months	0.999 (0.997, 1.000)	–
First VARAW in months	1.008 (1.006, 1.010) *	–
After VARAW time in months	0.995 (0.992, 0.998) *	–
Second VARAW time in months	0.999 (0.997, 1.002)	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed and calendar month and year and gender, as well as baseline age, body-mass index and smoking status. *P<0.01; **P<0.001.*

Among a subset of members who renewed the VARAW benefit for a third time (n=894), findings were again consistent from previous analyses, such that the first VARAW benefit period was associated with an average increase in physical activity days relative to the period before the first benefit. Physical activity levels were sustained in the period after the first benefit and during the second benefit period, albeit to a lesser degree, (Table 14). No statistically significant differences were observed in physical activity levels after the second benefit expired; however, the sample size is relatively small. Temporal trends in physical activity declined each month within each period.

The odds of a higher proportion of high-level physical activity days were statistically significantly higher in the second VARAW benefit period compared with before the first benefit period, with a gradual decline in high-level physical activity days within each period after the first benefit (Table 15).

Table 14: Negative binomial regression modelling output for the number of physical activity days per month among members who selected into at least three VARAW benefits.

	Incident Rate Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
Before first VARAW	Ref	[[omitted]]
During first VARAW	1.272 (1.232, 1.314) **	[[omitted]]
After first VARAW	1.236 (1.153, 1.324) **	Ref
Second VARAW	1.189 (1.209, 1.365) **	1.031 (1.000, 1.063)
After second VARAW	1.136 (1.010, 1.278)	Ref
Third VARAW	1.142 (1.014, 1.285)	1.005 (0.973, 1.038)
Overall time in months	1.002 (1.000, 1.004)	–
First VARAW in months	0.999 (0.998, 1.002)	–
After VARAW time in months	0.987(0.981, 0 .993) *	–
Second VARAW time in months	0.995 (0.993, 0.997) *	–
After second VARAW time in months	0.991 (0.984, 0.998) *	–
Third VARAW time in months	0.996 (0.993, 0.990) *	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed and calendar month and year and gender, as well as baseline age, body-mass index and smoking status. *P<0.025; **P<0.001.*

Table 15: Ordered logit regression modelling output for the proportion of days of high-level physical activity per month among members who selected into at least three VARAW benefits.

	Odds Ratios (95% Confidence Intervals)	
	Model Output	Postestimation
VARAW Status		
Before first VARAW	Ref	[[omitted]]
During first VARAW	1.053 (0.904, 1.228)	[[omitted]]
After first VARAW	1.254 (0.852, 1.846)	Ref
Second VARAW	1.661 (1.127, 2.447) *	1.324 (1.117, 1.572) *
After second VARAW	1.525 (0.778, 2.988)	Ref
Third VARAW	1.606 (0.821, 3.139)	1.053 (0.907, 1.221)
Overall time in months	0.999 (0.991, 1.008)	–
First VARAW in months	1.018 (1.006, 1.030) **	–
After VARAW time in months	0.968 (0.958, 0.989) **	–
Second VARAW time in months	1.007 (0.996, 1.019)	–
After second VARAW time in months	0.961 (0.935, 0.987) **	–
Third VARAW time in months	0.971 (0.952, 0.990) **	–

*Notes: VARAW, Vitality Active Rewards with Apple Watch. Point estimates and 95% CI shown with statistical adjustment for other factors listed and calendar month and year and gender, as well as baseline age, body-mass index and smoking status. *P<0.025; **P<0.001.*

3.4. Sensitivity Analyses

Findings from the sensitivity analyses are presented in Annex B (see Table B.1). Overall, physical activity data were missing more frequently for members who never accessed the VARAW benefit compared with members who did access the benefit. This is not surprising, given that the Apple Watch, as part of the VARAW benefit, is a source of data. For the relationship between VARAW benefit status and the number of physical activity days per month, this resulted in larger point estimates than our main analysis when physical activity days were imputed to '0' and smaller point estimates than our main analysis when physical activity days were imputed to the monthly maximum.

Similar findings were observed for the relationship between VARAW benefit status and the proportion of high-level physical activity days; however, imputation of physical activity days at the monthly maximum resulted in point estimates that were in the opposite direction to those in the main analysis.

Taken together, these findings suggest that the pattern of missingness of physical active days per month impacts the observed relationships between VARAW benefit status and outcomes, and the true effect sizes will depend on the degree to which missing values range from the two extremes (i.e. 0 to maximum physical activity).

4. Discussion

4.1. Summary of findings

This longitudinal, observational study aimed to examine the relationship between the VARAW benefit, as a loss-framed incentive, and long-term changes in physical activity. Specifically, we sought to address two main research questions. The first question was related to whether the uptake of the VARAW benefit among Vitality members corresponded to changes in physical activity relative to the Vitality Active Rewards programme alone, and whether these changes were sustained after the benefit expired. The second question was related to whether renewal of the VARAW benefit corresponded to changes in physical activity relative to the first benefit.

With regard to our first research question, and in line with findings from the first RAND Europe study [26, 27], the primary analyses showed that after adjusting for member baseline demographics and characteristics, time trends and calendar time, the first VARAW benefit period (which was on average 15.7 calendar months) was associated with an approximate 40% increase in the average number of physical activity days per month relative to the pre-VARAW period (which was on average 8 calendar months) or relative to members who never accessed the VARAW benefit (who had on average 17.3 calendar months of follow-up). In adjusted models, average rates of physical activity days remained elevated by approximately 20% during the post-VARAW benefit period (which was on average 14.2 calendar months) compared with the pre-VARAW period or compared with members who never accessed the benefit; this, however, represented a decline in physical activity days by an average of about 15% compared with the first VARAW benefit period. Similar results were observed for the proportion of high-level physical activity days. Thus, our findings are consistent with the first RAND report, but further show that physical activity is sustained for members who had an average follow-up 15.7 months during the VARAW benefit and, to a lesser extent, sustained through the post-VARAW period (for which members had an average follow-up of 14.2 months).

With regard to our second research question on the relationship between the renewal of the VARAW benefit and physical activity, our analyses showed that after adjusting for member baseline demographics and characteristics, time trends and calendar time, the second and third VARAW benefit periods (which were on average 14.3 and 8.1 calendar months, respectively) were associated with small, but statistically significant increases in incidence rates of physical activity days (13% and 11%, respectively) compared with the immediate periods before the VARAW benefit had expired (i.e. post-first VARAW [average of 14.2 calendar months] and post-second VARAW [average of 6.4 calendar months]). These levels of physical activity during the second and third VARAW benefit periods were statistically significantly lower compared with the first VARAW benefit period (-4.8% and -4.3%, respectively). Similar findings were observed for

the proportion of high-level physical activity days per month, with the exception that the second and third VARAW benefit periods were associated with increased odds of a higher proportion of physical activity days relative to the first VARAW benefit period (by 15% and 27%, respectively). These findings suggest a larger proportion of high-level physical activity days may be sustained with subsequent benefits relative to the first benefit. Although our descriptive summaries show, on average, higher levels of physical activity days (see Figure 3:1) as compared with the first VARAW benefit period, when adjusting for overall temporal trends, our statistical models showed that the effects of renewing the benefit were smaller.

Similar findings were observed in exploratory sub-analysis of members who selected into at least two or three benefits. Specifically, the effects on physical activity days were sustained relative to the period before the first benefit, albeit to a lesser degree; whereas the effects on high-level physical activity days were also sustained relative to the period before the first benefit, but were sustained or even increased through the second benefit period.

Overall temporal trends in physical activity were positive, indicating a general increase in physical activity and the proportion of high-level physical activity days each month over time. Our primary analyses showed that before the VARAW benefit was active or among those who never accessed the benefit, there was an increase over time in levels of physical activity, which could be associated with the gain-framed Vitality Active Rewards programme. Nevertheless, gradual negative trends were generally observed during each period of VARAW benefit activity/inactivity. These period temporal trends, coupled with the above findings on the effects of the VARAW benefit, suggest that the effect of incentives in motivating behavioural change may wane over time, especially when the VARAW benefit is no longer active. Similarly, our secondary analyses showed that second and third VARAW benefits may have smaller effect sizes compared with the first benefit, given that members pay higher upfront costs for subsequent Apple Watches. Nevertheless, and as we can glean from our exploratory analyses, levels of physical activity are sustained during first and subsequent benefit periods compared with the period before the first benefit was active.

Our findings of waning effects are consistent with reports from the academic literature. For example, two systematic reviews found that while mobile health interventions often increase physical activity in the short term, effect sizes decrease over the long term [28, 29]. Similarly, another systematic review and meta-analysis found that in inactive adults, physical activity interventions are effective in increasing physical activity, and that effects are sustained to a lesser extent after six months or more post-intervention [30].

In our analysis, it is difficult to tease apart the effects on physical activity that are attributable to loss-framed incentives of the VARAW benefit or the gain-framed incentives of the Vitality Active Rewards programme. Previous research of a smoking cessation intervention that had either gain- or loss-framed incentives found that those in the loss-incentive group abstained from smoking for at least one day, and also reduced the amount smoked compared with the gain-incentive group [31]. However, the gain-incentive group were more likely to maintain abstinence once initiated [31]. Loss aversion (also known as prospect theory) suggests that the feelings of loss if someone fails to complete something can be more motivating than a reward of equal value as the loss for completing something successfully [24, 32]. This is potentially because the emotional response (e.g. distress, anxiety, fear) is experienced more intensely in loss than for a reward [33]. More research is needed to understand the impacts of gain- and loss-framed incentives alone and in combination.

Our analysis also found that independent of the VARAW benefit and time trends, certain baseline demographic factors were associated with higher levels of physical activity and a higher proportion of high-level physical activity days. Specifically, higher levels of physical activity were found among adults 35 years of age or older as compared with those 18 to 34 years of age, males as compared with females, never smokers compared with ever smokers and those with BMI in the healthy range as compared with underweight, overweight or obese. We explored if the effects of the VARAW benefit were different by baseline BMI categories, and while some differences were observed, caution should be used in interpreting these findings as this analysis was conducted on a small subset of the total sample (<20%) due to the large number of missing values at baseline.

4.2. Implications

Physical activity has important health benefits, including a reduced risk of cardiovascular disease [1-3], diabetes [4, 5], cancer [6, 7], mental health conditions [8, 9] and all-cause mortality [10-13]. Understanding ways to incentivise physical activity is central to improving individual and population health, as well as reducing the burden on health and social care systems. In this study we show that the VARAW benefit is associated with increases in both the number of days of physical activity and the proportion of days of high-level physical activity per month. Both tend to wane over time, especially after the benefit expires; however, the overall effect on physical activity was sustained compared with periods when the benefit was not active. Notably, renewal of the VARAW benefit for a second and third time appears to be associated with a lower number of physical activity days per month, compared with the first benefit, but an increase in the proportion of days of high-level physical activity per month. Whether these findings for physical activity, particularly increases in high-level physical activity days, translate into reductions in morbidity or mortality cannot be determined from the current study, but future research in this area is warranted.

4.3. Limitations and strengths

There are several limitations to consider when interpreting findings from this study. First, Vitality members are privately insured individuals, who may not necessarily be representative of the wider UK population. Approximately only 10.3% of the UK population has private health insurance [34] and 35% has life insurance [35]. Insured beneficiaries are more likely to be higher-income earners, and may also be generally more healthy (e.g. less likely to smoke) relative to the UK population without private insurance [36]. Previous research of a similar physical activity digital intervention found that there were no effects on physical activity in lower socio-economic status individuals, but that the intervention was effective in people of high socioeconomic status [37], pointing to potential limits in the generalisability of the findings from this study to other populations.

Second, Vitality members self-selected into both the VARAW benefit and the Vitality Active Rewards programme more broadly. Hence, there is a high likelihood for selection bias in that members who chose to access these incentive programmes may be different from other Vitality members who did not choose to access these programmes, and both groups may be different from the wider population. We expect that over time there is also natural attrition of Vitality Activity Reward members if they are no longer insured with

Vitality (e.g. in the case of switching employers). In addition, those who selected into a second and third VARAW benefit may also differ from those who only accessed the first benefit. Our analysis shows that those who chose to access the VARAW benefit were engaged in higher levels of physical activity during the pre-VARAW benefit period compared with those in the Vitality Active Rewards programme who never accessed the VARAW benefit. This signals key between-group differences, which may influence the relationships observed between VARAW benefit status and outcomes, beyond those that were taken into account in the models for this study. As such, unmeasured confounding is an important limitation for our analysis. Previous research found that those who have most to gain from gain-loss incentives using wearables for physical activity tend not to select into these incentives [38].

Third, while this study used physical activity outcomes that were measured by wearable smart devices, the collection of these data depended on the members wearing these devices. Indeed, physical activity measurements were missing intermittently across the observation period. We conducted sensitivity analyses by imputing missing outcome measurements. Because outcomes were missing more frequently for those who never accessed the VARAW benefit (and were more likely missing in the pre-VARAW period), when missing values were imputed to '0' effect sizes for the relationship between the VARAW benefit and physical activity were larger than those in our main analysis, and when missing values were imputed to the potential maximum monthly value effects, sizes were smaller and in some cases in the opposite direction. Thus, while either extreme is unlikely, the true effect size likely lies somewhere in between.

Fourth, previous research suggests that loss-framed incentive programmes for behavioural change can have unintended consequences and lead to participants (mis)behaving, cheating or 'gaming' the system [39, 40]. In the case of the VARAW benefit, to avoid paying a large sum for the Apple watch, members may resort to 'gaming' the system (e.g. allowing others to wear the watch, shaking the watch), which could show increased or sustained physical activity, while no physical activity for that member took place. Thus, this could lead to spurious physical activity measurements among members who access the VARAW benefit. In addition, those who continue to select into the benefit (second and third VARAW benefits) may engage in physical activity regardless of the incentive, making it challenging to assess whether the incentive impacts physical activity behaviours or whether individuals capitalise on benefits based on existing behaviours.

Lastly, and as mentioned earlier, we cannot discern effects that are due to the loss-framed incentives versus the gain-framed incentives, or both. Similarly, we cannot parse the effects of either of these incentives from those of receiving an Apple Watch, which in itself could have been an incentive to engage in healthier behaviours.

Despite these limitations, our study has important strengths. First, we used a large longitudinal cohort of more than 600,000 Vitality members with over 13 million physical activity observations recorded over a five-year period (average follow-up was 24 months). Such large studies on behavioural incentives are generally absent from the literature. Second, we used a quasi-experimental method (i.e. interrupted-time series) to understand associations between physical activity outcomes and several periods of time in which the VARAW benefit was accessed, as well as periods before the benefit was accessed and after the benefit had expired. The analysis also benefited from having observations for members who never accessed the VARAW benefit. Lastly, the examination of relationships between second and third benefit (incentive) periods and physical activity is novel. Taken together, and although causal inferences are limited, this study

provides an important contribution to the current evidence on the potential impact of insurance benefit incentive programmes.

4.4. Conclusions

Findings from this longitudinal, observational study of Vitality Active Rewards programme members from the UK indicate that the first VARAW benefit is associated with an increase in physical activity days per month, as well as a higher proportion of high-level physical activity days, relative to before the start of the VARAW benefit or compared with never accessing the benefit. Furthermore, these effects appear to be sustained after the first VARAW benefit expires, although to a slightly lesser extent compared with when the benefit is active. Lastly, despite waning effects over time and a decrease in the number of physical activity days, a higher proportion of high-level physical activity days appears to be sustained with subsequent VARAW benefits, at least while these benefits are active. Taken together, these results suggest that although the magnitude of increases in physical activity tend to be lower with each subsequent benefit, the overall effects on physical activity, especially the proportion of high-level physical activity, appear to be sustained over time.

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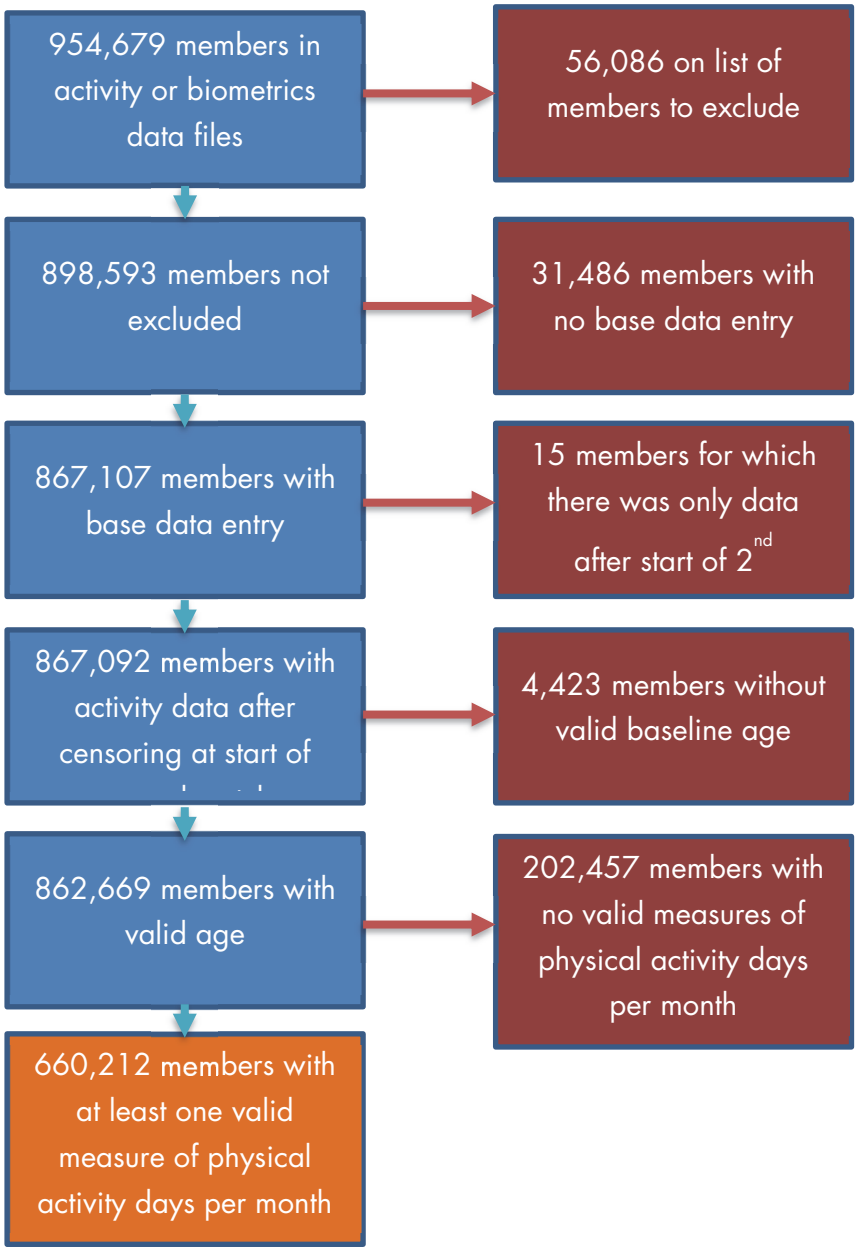
Annex A. Member flow chart

Figure A.1: Member flow chart representing eligibility for inclusion in analysis.



Annex B. Sensitivity analyses

Table B.1: Imputation of missing physical activity days for primary analyses

Outcome = Number of Physical Activity Days Incident Rate Ratios (95% Confidence Intervals)			
	Model 2: no imputation	**Model 2: impute to 0**	**Model 2: impute to max**
VARAW Benefit Status			
Before/Never VARAW	Ref	Ref	Ref
During VARAW	1.405 (1.401, 1.408) *	2.114 (2.105, 2.123) *	1.068 (1.066, 1.070) *
After VARAW	1.196 (1.191, 1.201) *	1.400 (1.389, 1.412) *	1.055 (1.052, 1.058) *
Overall time	1.003 (1.003, 1.003) *	1.004 (1.004, 1.005) *	1.002 (1.001, 1.002) *
Time during VARAW	0.996 (0.996, 0 .996) *	0.990 (0.989, 0.990) *	0.999 (0.999, 0 .999) *
Time after VARAW	0.996 (0.9956, 0 .996) *	0.996 (0.996, 0.997) *	0.997 (0.997, 0.997) *
Outcome = Proportion of High-level Physical Activity Days Odds Ratios (95% Confidence Intervals)			
	Model 2 no imputation	**Model 2 impute to 0**	**Model 2 impute to max**
VARAW Benefit Status			
Before/Never VARAW	Ref	Ref	Ref
During VARAW	1.637 (1.620, 1.654) *	2.803 (2.783, 2.824) *	0.651 (0.647, 0.655) *
After VARAW	1.634 (1.602, 1.667) *	1.691 (1.667, 1.715) *	0.960 (0.949, 0.971) *
Overall time	1.002 (1.002,1.002) *	1.002 (1.002, 1.002) *	1.000 (1.000, 1.000)
Time during VARAW	1.002 (1.002, 1.002) *	0.990 (0.989, 0.990) *	1.011 (1.011, 1.011) *
Time after VARAW	0.992 (0.991, 0.992) *	0.999 (0.999, 1.000)	0.996 (0.995, 0.996) *

*Notes: Model output represents estimates adjusted for age, gender, baseline body-mass index and smoking status. VARAW, Vitality Active Rewards with Apple Watch. *P<0.001.*