



A digital health programme's impact on mortality: Analysis into LumiHealth – a partnership between the Singapore government and Apple

Executive Summary

LumiHealth is a health and wellness engagement programme developed in partnership between the Singapore government and Apple that incentivizes lifestyle-based improvements for its participants. Singapore's Health Promotion Board (HPB) collaborated with Swiss Re to analyse aggregated and anonymized data from LumiHealth to understand the programme's effectiveness, including quantifying the possible impacts of the programme on mortality.

The analysis shows that LumiHealth participants who engaged with the programme for five or more months increased their levels of physical activity, which Swiss Re estimates may result in meaningful future reductions in all-cause mortality. Swiss Re's

analysis estimates the potential mortality reductions based on increased activity levels and demonstrates that they are most likely larger for participants who are more at-risk, such as those who are overweight or obese, the elderly or those with prior sedentary behaviour.

This paper also estimates the probable Life insurance claims cost savings that may result from mortality reductions such as these. This helps drive further understanding on the impact of digital health programmes for insurers. This approach may help inform other stakeholders as they determine the benefit of assessing or implementing similar digital health programmes.

Key findings

These findings are for a subset (30 000 participants) of the total eligible population that participated in the LumiHealth programme for between five months and two years, covering the period Jan 2022 to Dec 2023 and had generated sufficient data to perform the evaluation. Since these findings are based on a short period, when estimating the mortality reductions, there is an **assumption that the improved physical activity is sustained until old age** (participants aged 30–50 sustain activity levels until age 65, whereas participants aged >50 sustain activity levels for 20 years). As a result, **these findings represent an upper-end estimate** of the expected impact and may differ across other programmes and populations.



Participants opened the app ~2.3 days per week on average, and **more highly engaged participants showed larger increases in activity levels.**



Participants averaged a **22% increase in their daily active calories burned** during the programme compared to pre-programme levels, with larger improvements for some of the key at-risk groups such as those with high BMI, pre-programme sedentary activity and the elderly.



The increased physical activity could result in an estimated **average mortality reduction of between 3% and 13%** (and up to 20% for some of the key at-risk groups) based on a portfolio of all the LumiHealth participants, assuming the activity improvement is sustained until old age.

About the LumiHealth programme

LumiHealth is a health and wellness engagement programme developed in partnership between the Singapore government and Apple, as part of Singapore's Smart Nation initiative. The programme is administered via a mobile application that integrates participant health information with data from Apple Watch and iPhone, including to recommend personalized content, notifications, and goals. It offers incentives, as well as Apple's ecosystem of features, to help participants focus on their physical activity, nutrition, mental wellbeing, sleep, and chronic condition management.

The data behind Lumihealth

Eligible residents who wish to join the programme must consent to participate, and may agree to share data such as their demographics, survey responses, and health and fitness data collected from sensors in Apple Watch and iPhone with the LumiHealth programme.

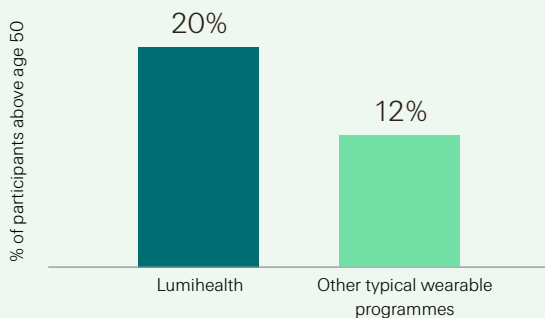
Participants may also agree to provide a subset of health and fitness data from a short duration of time prior to joining LumiHealth. This historical data is not usually available in other digital health programmes and provides a unique ability to compare LumiHealth programme levels of physical activity for a participant with their pre-programme levels.

The total number of participants in the LumiHealth programme as of 31 Dec 2024 was 226 000. 30 000 were included in this analysis (filtering is described in the section below labelled "Setting the baseline with active calories").

LumiHealth is not only for the healthy

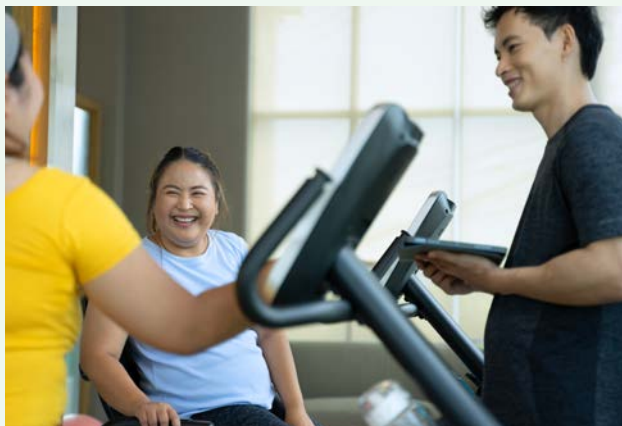
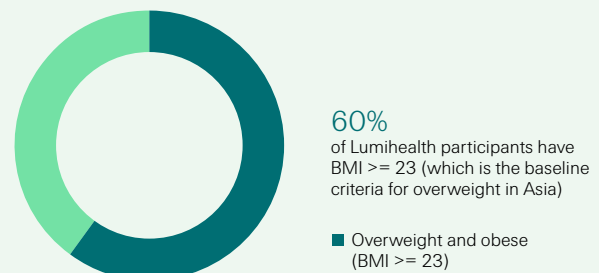
There is a common perception that wearable-based programmes attract only healthy and physically active participants. LumiHealth appears to attract and retain a higher percentage of people who would not typically be considered healthy or expected to engage with wearables.

More older people

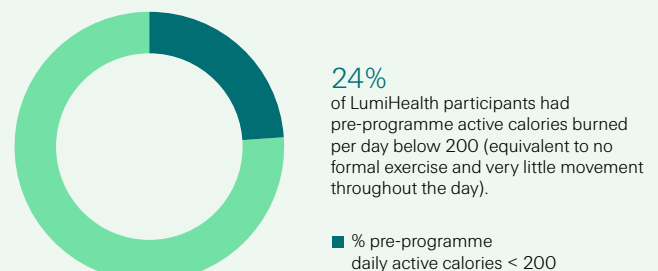


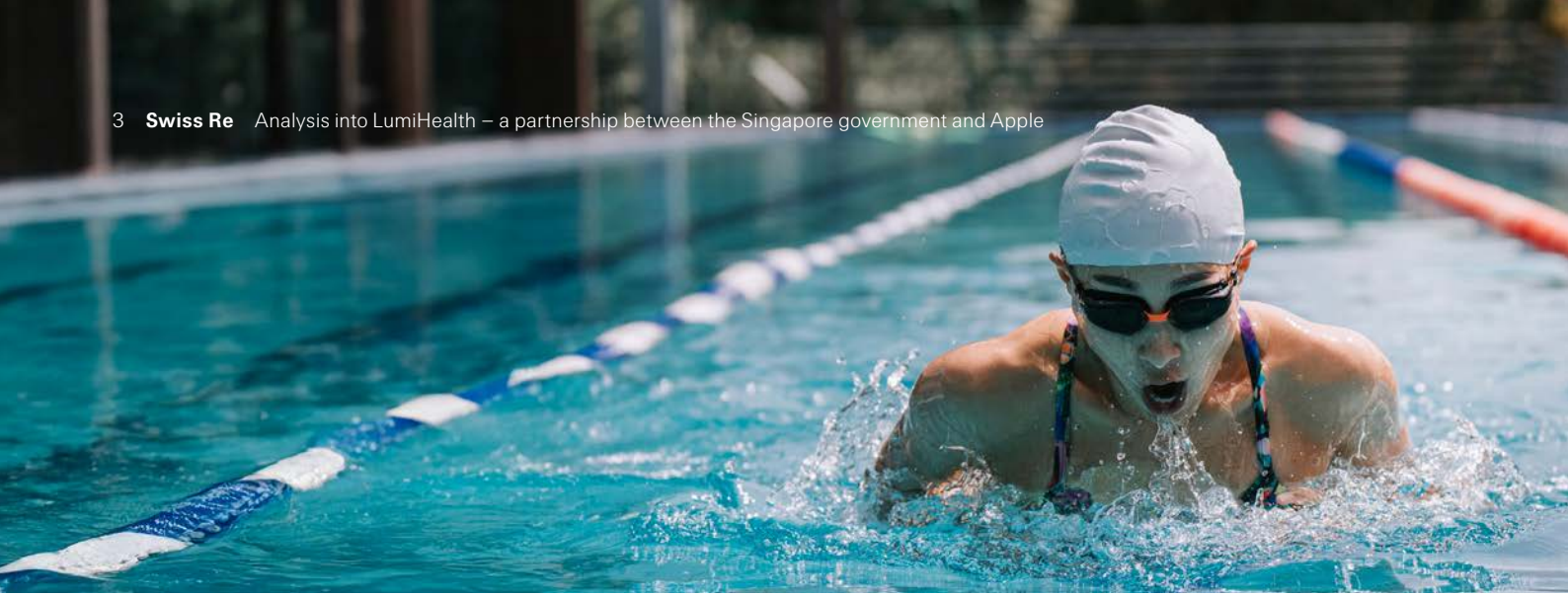
Source: Swiss Re internal global data

High proportion of overweight and obese



Significant proportion of participants were inactive prior to joining LumiHealth:





Modelling methodology for mortality impacts

The focus of Swiss Re's analysis was on the physical activity data and its impact on mortality. The assessment of the LumiHealth programme compares participants' pre-programme active calories burned with active calories burned during the programme to determine the projected mortality change.

Swiss Re has previously conducted extensive research into the "Big Six lifestyle risk factors"¹. These risk factors are physical activity, nutrition, mental wellbeing, sleep, environment and substance abuse. The physical activity research² shows how improved physical activity, measured in MET³ (Metabolic Equivalent of Task), is a key factor in reducing all-cause mortality. MET is another comprehensive measure of physical activity, similar to active calories. LumiHealth data does not contain MET, therefore active calories were used as the starting measure of physical activity and were then transformed to MET.

Mortality data was not collected as a part of the programme, which meant it was not feasible to perform a longitudinal analysis with observed death data. Instead, potential mortality reduction was estimated by modelling mortality outcomes for the 2-year period. Two different approaches were used for modelling, both based on data models driven by Swiss Re research.

The two-year period covered in this analysis is a relatively short period for a mortality analysis. To model the longer-term impact on mortality, it is assumed that the improved MET levels seen over the 2-year period are sustained until old age. Old age is defined such that participants aged 30–50 sustain activity levels until age 65, whereas participants aged >50 sustain activity levels for 20 years. The approach was as follows:



1. Setting the baseline with active calories:

LumiHealth programme levels were compared with pre-programme levels across LumiHealth participants to identify positive behaviour change. The results shown in this section include:

- a. The increase in active calories burned driven by programme participation
- b. The dose effect on active calories associated with at-risk populations



2. Transformation to MET:

Active calories were transformed to MET



3. Estimating mortality impacts:

The mortality impacts resulting from improvements in MET were modelled using two approaches:

- a. **Approach 1:** Using Swiss Re's Cardiometabolic Underwriting Model, which is built on Swiss Re's underwriting manual
- b. **Approach 2:** Using the latest research into physical activity impacts derived from a UK Biobank study based on Swiss Re's partnership with the University of Oxford

¹ "The Big Six" Lifestyle Factors, Swiss Re, February 2020

² How does activity affect longevity, Swiss Re, August 2020

³ B.A. Franklin, et. al., Using Metabolic Equivalents in Clinical Practice, The American Journal of Cardiology, 2018

1 Setting the baseline with active calories

Active calories are a comprehensive representation of a participant's physical activity level since they combine the type of activity, intensity and duration all within one value.

To run an analysis on the active calories data, it was necessary to study the data for those participants who had provided sufficient active calories data both before the LumiHealth programme and during the programme. The LumiHealth data was therefore filtered to identify participants with active calories data of at least 1-month pre-programme and 5-months during the programme, providing statistically credible and stable results. This resulted in a subset of 30 000 participants from the initial total of 226 000 participants.

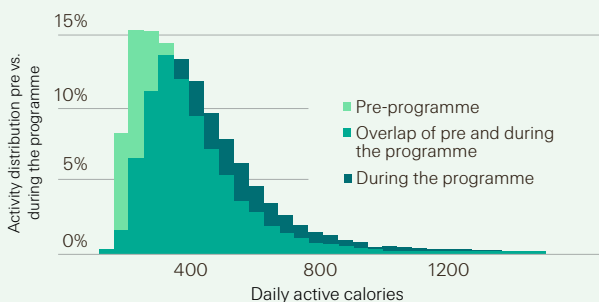
Comparisons between the filtered dataset and the total LumiHealth dataset showed statistically very similar active calories burned during the programme, as well as age and gender profiles. This allowed for the assumption that the filtered dataset would be a good proxy for the total LumiHealth dataset.

From this point, all graphs and data refer to the filtered LumiHealth dataset. However, these results could be generalized to the total LumiHealth dataset given the similarities of the two populations.

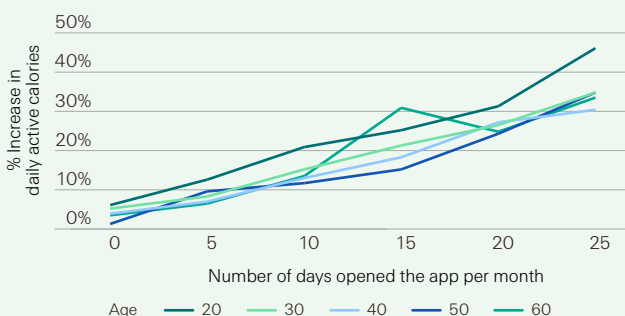
Daily active calories graphs

1a) Increase in daily active calories burned driven by programme participation

The graph below shows the distribution of daily active calories comparing pre-programme levels to levels during the programme. Median daily active calories across all participants increased from 334 (pre-programme) to 407 (during the programme), a **22% increase**. This is equivalent to adding around 20 minutes daily of moderate-to-vigorous physical activity. This mainly occurred through a large increase in active calories burned for participants upon joining LumiHealth, with those remaining experiencing a small additional rise during the programme. This increase was relatively stable across differences in participants programme duration.



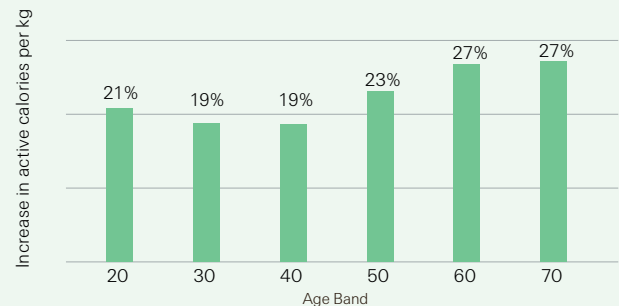
Participants engaged with the programme regularly, with people opening the app 2.3 days per week on average. App usage increased by age with seniors exhibiting the highest app usage of 2.8 days per week. The graph below shows a strong correlation between LumiHealth app usage and increase in active calories burned. This was consistent across different age bands.



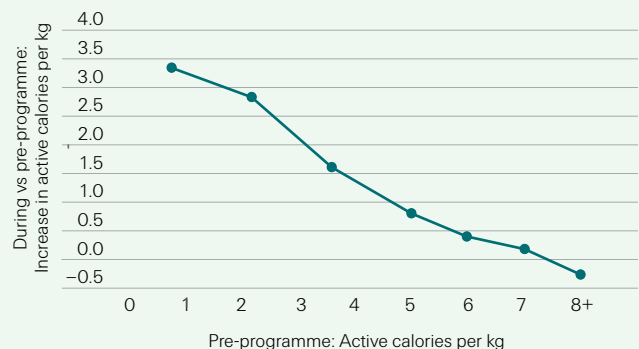
1b) Dose effect on active calories associated with at-risk populations

The change in daily active calories was greater in the at-risk groups such as the elderly as well as participants who were inactive prior to joining LumiHealth.

The average daily active calories per kilogram across LumiHealth participants was higher for the older ages. In addition, the graph below shows that the increase in daily active calories due to LumiHealth was also highest for ages above 60.



The graph below shows that the increase in average daily active calories per kilogram across LumiHealth participants was highest for those who were initially sedentary and had low pre-programme daily active calorie levels.



These results are encouraging as they indicate that LumiHealth is making a difference for the at-risk population which is meaningful for both individual and population health.

2 Transformation to MET

To model the physical activity changes on mortality, active calories burned were transformed into the metabolic equivalent of task (MET) measure for each participant. This adjustment was made since the Swiss Re models and most publicly available physical activity models are largely based on MET.

3 Methods used for estimating mortality impacts

Approach 1:

Swiss Re's Cardiometabolic Underwriting Model

Swiss Re's Cardiometabolic Underwriting Model⁴ is a part of Swiss Re's Life and Health insurance global underwriting manual which combines medical, underwriting, and actuarial expertise. It is built using the evidence base sitting behind Life Guide, Swiss Re's underwriting manual⁵. It includes all-cause mortality relative risk assessments for MET, split by various factors such as age, gender and starting MET levels.

This approach probably underestimates the potential mortality impact since the LumiHealth data evaluated in this study included only METs. Therefore, the impact of second-order effects to cardiometabolic health, such as changes in body mass index (BMI) and blood pressure, could not be modelled.



Approach 2:

UK Biobank study modelling

An alternative approach was to leverage Swiss Re's recent partnership with the Nuffield Department for Population Health of the University of Oxford to map all-cause mortality relative risk by MET. This research,⁶ derived from the UK Biobank accelerometer data, shows some associations between step count in the Biobank data and all-cause mortality.

This approach has some benefits of improved estimation such as the inclusion of second-order effects associated with increased physical activity (i.e., their impact on improvement in hypertension and diabetes, etc.), which Approach 1 does not include. However, this approach does not make a distinction between causation and correlation. In addition, the research is based on established long-term physical activity, as opposed to the analysis of the LumiHealth programme which assesses adoption of new habits during a shorter period. Accordingly, this approach provides an upper bound to the mortality impact estimate.



⁴ Supercharge your risk assessment with the Cardiometabolic Calculator, Swiss Re, September 2021

⁵ Life Guide: moving forward in Life, Swiss Re, February 2025

⁶ S.R. Small, et al., 'Development and Validation of a Machine Learning Wrist-worn Step Detection Algorithm with Deployment in the UK Biobank' preprint on medRxiv, submitted 2023

Results: Impact on mortality and claims costs

For each of these two approaches, per-participant all-cause mortality reductions were estimated based on the per-participant change in MET levels. The estimated portfolio mortality impact was then calculated for each approach, as the average mortality change across all LumiHealth participants.

This resulted in a range of estimated average mortality reductions for a portfolio of all the LumiHealth participants **from 3% to 13%** with the lower bound represented by the Swiss Re Cardiometabolic Underwriting Model and the upper bound represented by the UK Biobank modelling. This range assumes that the MET improvements seen over two years are sustained until old age.

The analysis also assessed potential Life insurance claims cost saving, with the claims cost savings applied to the required Life insurance coverage. The Life insurance coverage in Singapore

required to appropriately cover each adult is 500 000 SGD. This is based on the sum of the average existing levels of insurance and the average protection gap as derived by the Life Insurance Singapore Association in their 2022 Protection Gap study – Singapore⁷.

As an illustrative example, using the 500 000 SGD as an average sum assured for a term Life insurance product, along with the age structure of a digital health and wellness programme like LumiHealth, the mortality reductions derived above may correspond to an estimated reduction in monthly claims cost of **between 2 to 8 SGD per person**, with this savings variation based on type of covers, payment term, insurers rates, and the insurer's insured profile. While not directly studied here, other costs such as healthcare and medical claims costs may experience corresponding reductions, which would enable cost savings for insurers, individuals, and healthcare systems.

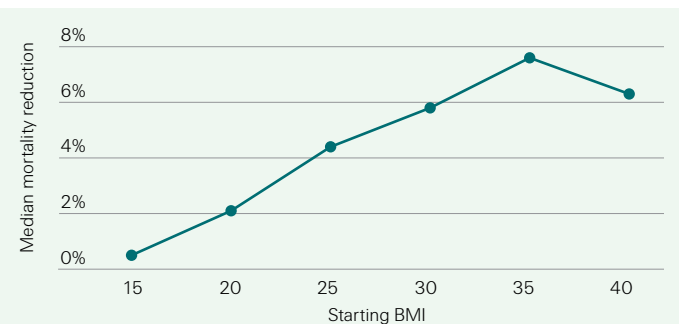
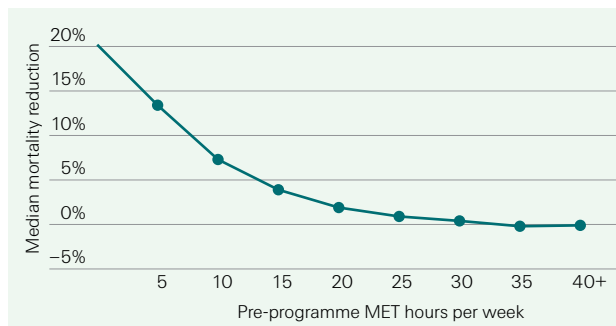
Mortality impacts by sub-group (based on Approach 1)

Using the Swiss Re Cardiometabolic Underwriting Model, mortality reductions can be assessed by sub-group. This is especially helpful for the at-risk groups where the impact is often more profound and the potential for mortality reductions is greater. Since these estimates are based on Approach 1, they do not include second-order effects. Therefore, it is expected that actual mortality reductions could be larger in practice.

The projected mortality reductions are greater for those who had low pre-programme activity levels. The graph below shows the median mortality reduction split by pre-programme MET hours per week levels across LumiHealth participants. For

participants with very low pre-programme MET levels, who for example perform the equivalent of three additional 30-minute walks a week, the estimated mortality reduction is between 15%–20%, whereas the magnitude of reductions is significantly smaller for those participants with a high pre-programme level of MET hours per week.

There was a correlation between participants who had starting BMI levels that were overweight and obese with achieving substantially larger estimated mortality reductions. The graph below shows that the median estimated mortality reduction is more significant as starting BMI levels increase.



Caveats of the data selection and modelling approach

The estimated mortality reductions in this analysis are based on active calories data, with per participant data ranging from 5 months to 2 years. This is a relatively short period for a mortality analysis. To estimate the long-term mortality impact of these changes in behaviour, it is therefore assumed that the improved activity levels will be sustained until old age. Old age is defined such that participants aged 30-50 sustain activity levels until age 65, whereas participants aged >50 sustain activity levels for 20 years. These modelled outcomes are true for sustained behaviour, and we will see reduced outcomes if participants disengage. In addition, the loss of incentives after exiting the programme could reduce the impact of the previously achieved improvements.

These findings were based on the LumiHealth programme, which includes a population specific to Singapore but that may not be fully representative of the Singaporean population, and which uses an incentive structure that supports sustained behaviour change. Because this programme is broadly available (and not a research study) we cannot control for selection bias that may exist when deciding to participate. Therefore, results may vary in participant groups with different starting health levels, reside in a different country, or participate in a programme with an alternative incentive structure.

⁷ 2022 Protection Gap Study – Singapore, Slide 18, Life Insurance Association Singapore, September 2023



Summary

This analysis of the LumiHealth programme shows that those who participate for at least several months experience physical activity improvements, which if maintained over the long-term could result in meaningful mortality reductions based on Swiss Re's modelling. These mortality reductions would be expected on average across the LumiHealth participant portfolio and are estimated to be larger for the at-risk groups (those who are elderly, obese or were previously sedentary). Mortality reductions at this level

across a similar population may lead to potential Life insurance claims cost savings which may be impactful for Life insurers and governments. This approach used here may help inform stakeholders to assess other types of digital health programmes; while considering the short-term nature of the observation period, the sustainability of the physical activity improvements over the long-term and the impact of the specific programme features.

Competing interest statement

Singapore's Health Promotion Board collaborated with Swiss Re to analyse aggregated and anonymized data from LumiHealth to understand the programme's effectiveness, including quantifying the possible impacts of the programme on mortality. HPB and Apple both provided an overview of their programme operations and helped Swiss Re identify the relevant and useful data for the analysis. No funding was provided by HPB or Apple in this assessment.

Swiss Re is an international reinsurer with operations in Singapore. Swiss Re was not involved with the set-up or design of the LumiHealth programme nor is the company affiliated with Apple Inc.

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