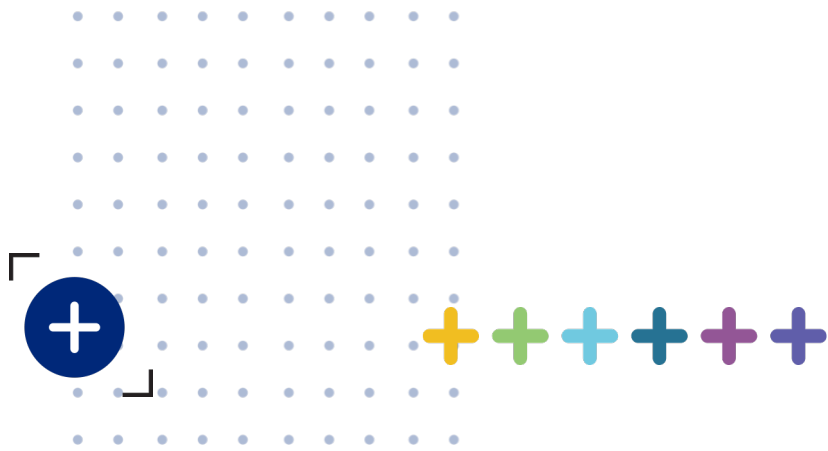# Sleep, wearables and the future of underwriting

The Poor Sleep Epidemic

The poor sleep epidemic

15% of people sleep less than the recommended number of hours

21% of adults in the US are getting less than 6 hours of sleep per night

1/3rd of adults are not finding their sleep sufficient

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Some human necessities

| | Food | Water | Air | Sleep |

Some human necessities

	Food	Water	Air	Sleep
Rule of thumb	1-3 weeks	2-4 days	3 min	Not clear **but** extreme symptoms after 36 hours

Some human necessities

|	Food	Water	Air	Sleep
Rule of thumb	1-3 weeks	2-4 days	3 min	Not clear **but** extreme symptoms after 36 hours
Record	382 days or 74 days	18 days	11 min & 35 sec	11 days

Sleep and Morbidity
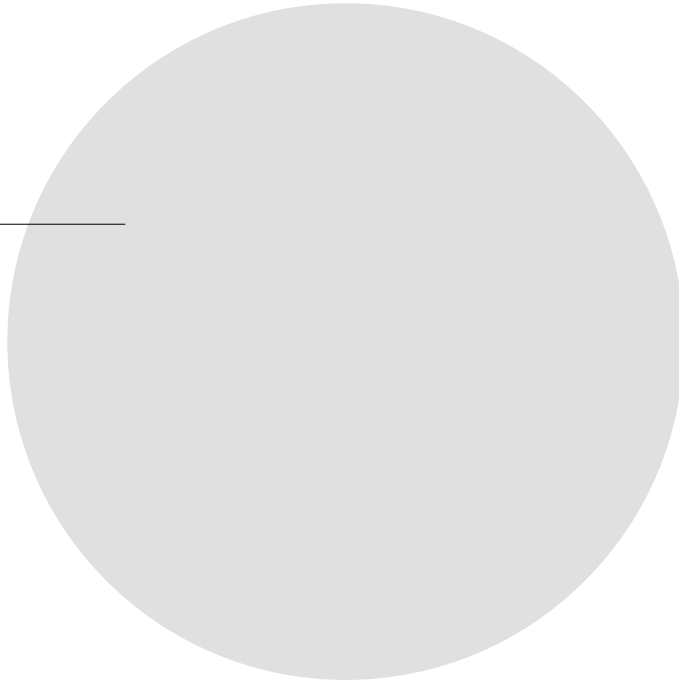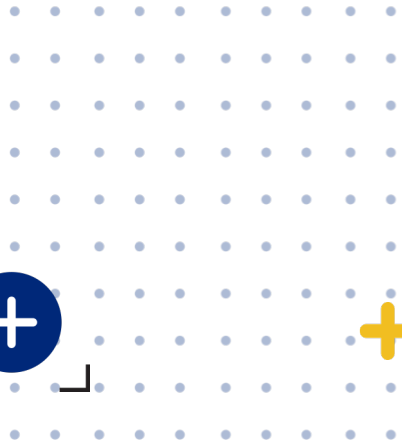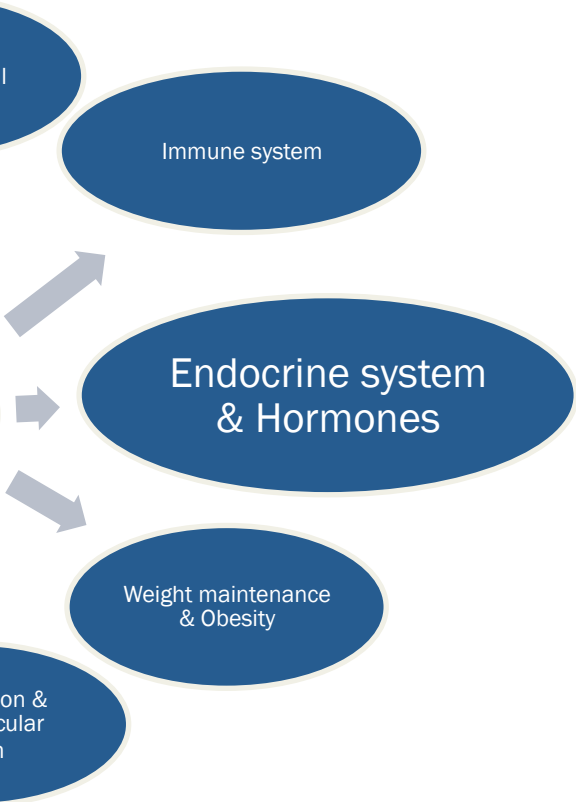
Literature review framework
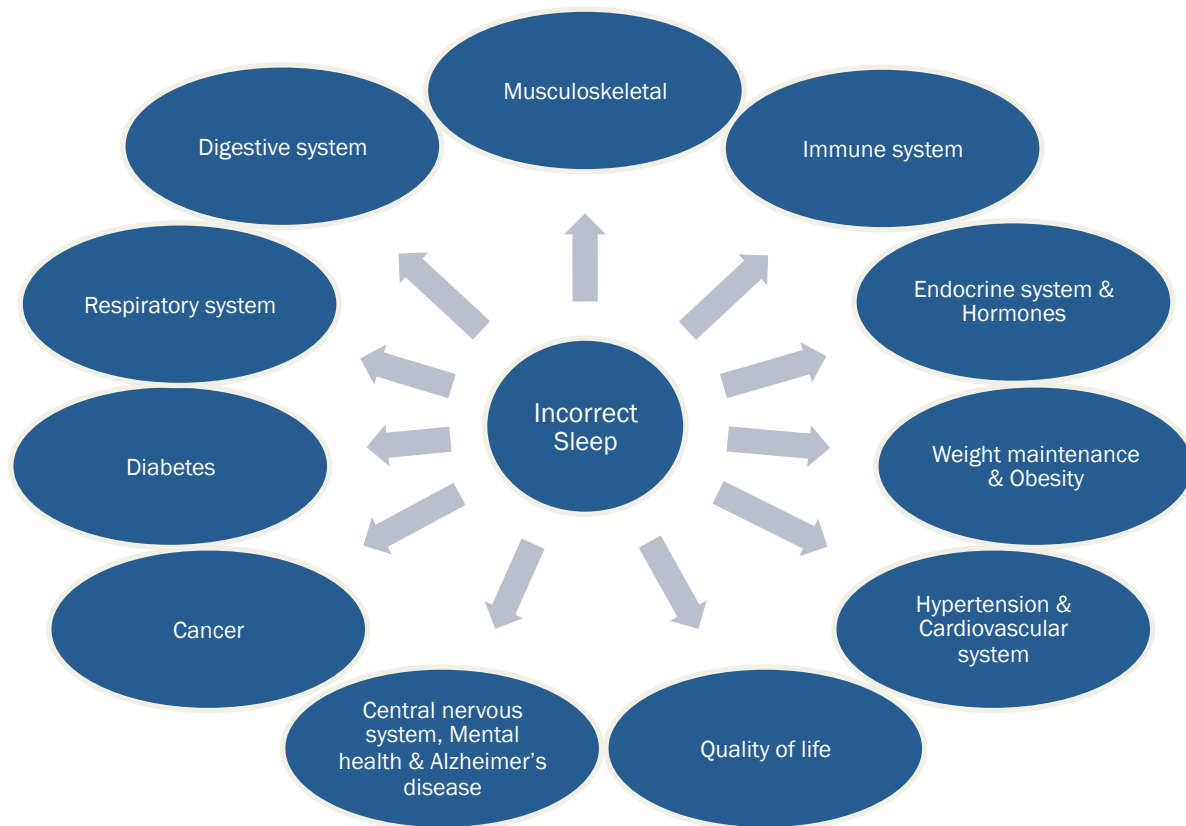
We started with an in-depth literature review to understand what research tells us on the impact of poor sleep on the health of an individual and its effect on mortality.

We structured this literature by reviewing what studies inform us about the impact of sleep on each of the major body systems.
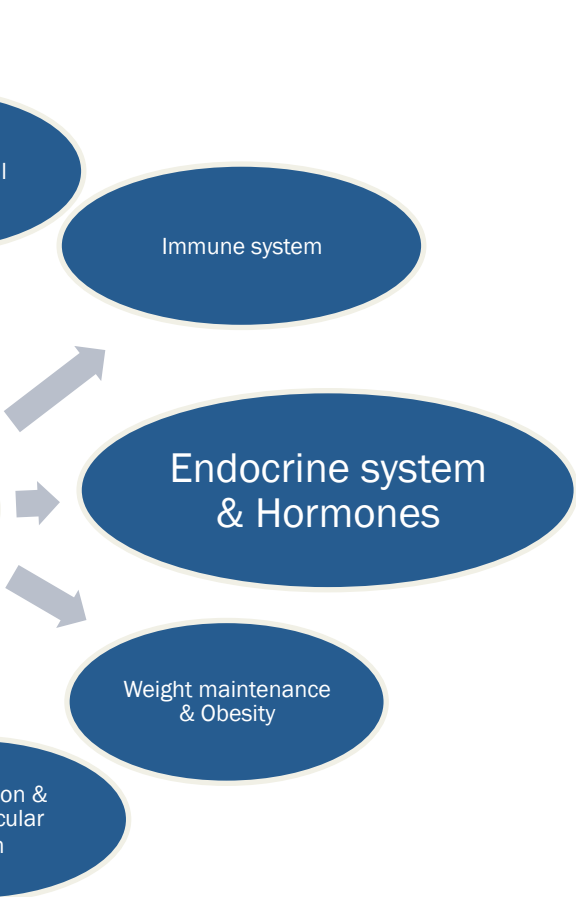
Immune system

Endocrine system
& Hormones

Weight maintenance
& Obesity

Several nights of just 4 hours of sleep in otherwise healthy
individuals impairs blood sugar regulation to such an extent
that they would be classified as pre-diabetic

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Immune system

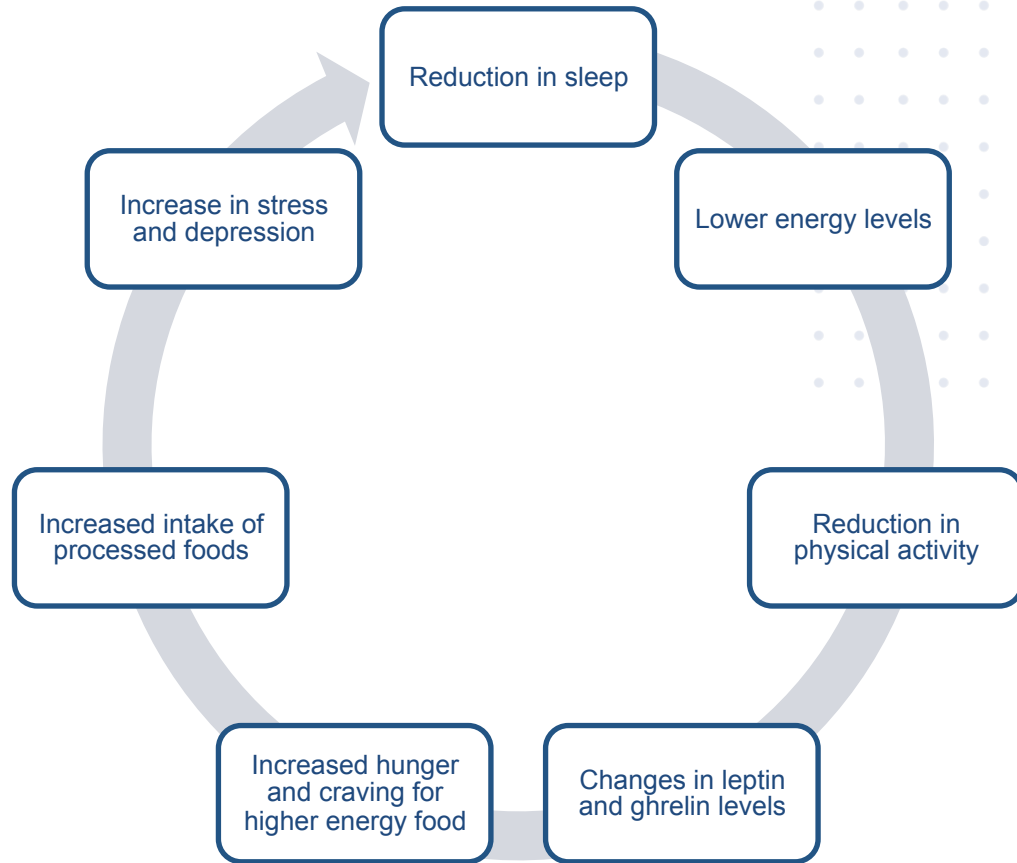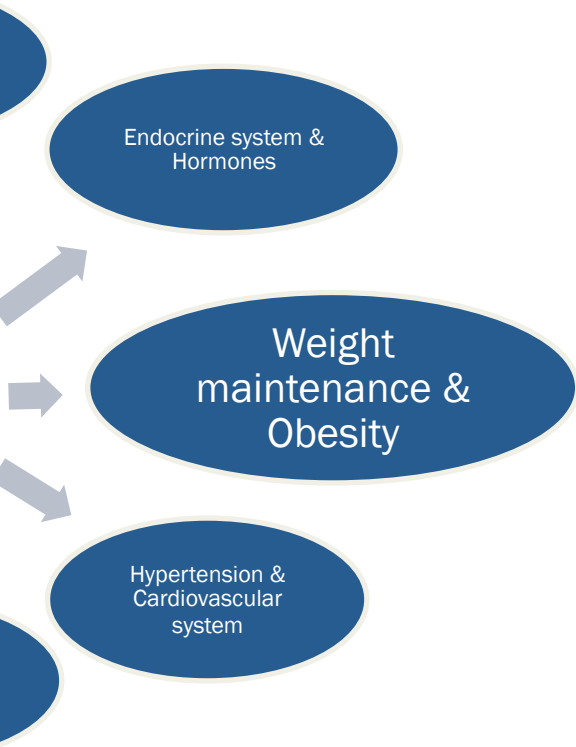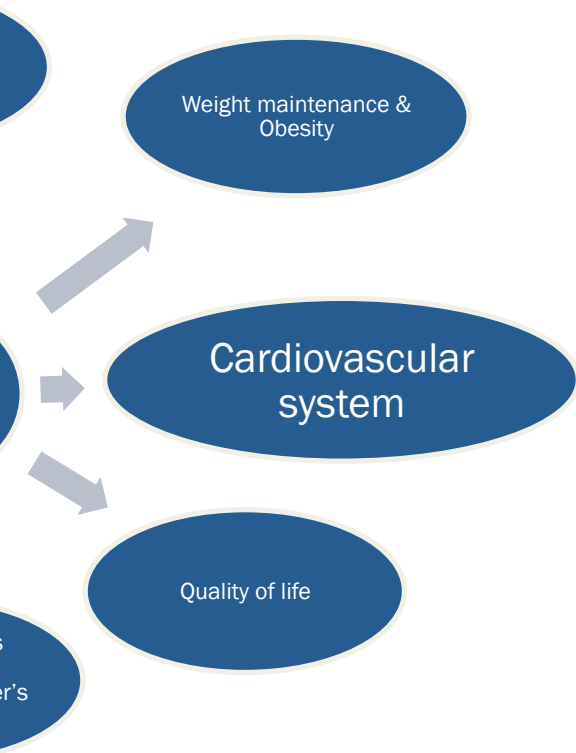Endocrine system
& Hormones

Weight maintenance
& Obesity

Several nights of just 4 hours of sleep in otherwise healthy individuals impairs blood sugar regulation to such an extent that they would be classified as pre-diabetic

The impact of sleep loss on glucose metabolism may promote the development of obesity, diabetes, and other endocrine/hormonal conditions, further reducing quality of life and negatively impacting longevity

Endocrine system & Hormones

Weight maintenance & Obesity

Hypertension & Cardiovascular system

Reduction in sleep

Lower energy levels

Reduction in physical activity

Changes in leptin and ghrelin levels

Increased hunger and craving for higher energy food

Increased intake of processed foods

Increase in stress and depression

Weight maintenance & Obesity

Cardiovascular system

Quality of life

Coronary heart disease and strokes were strongly associated with either short or long sleep durations for either developing or dying from the condition

Weight maintenance & Obesity
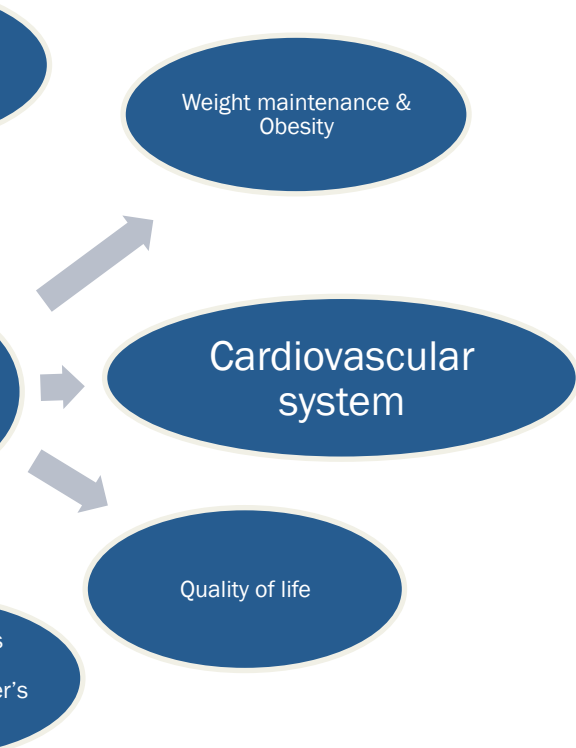
Cardiovascular system

Quality of life
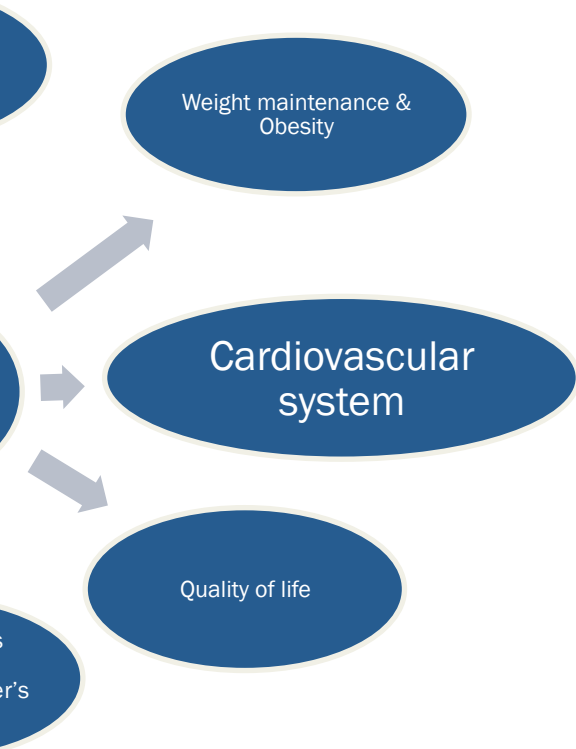
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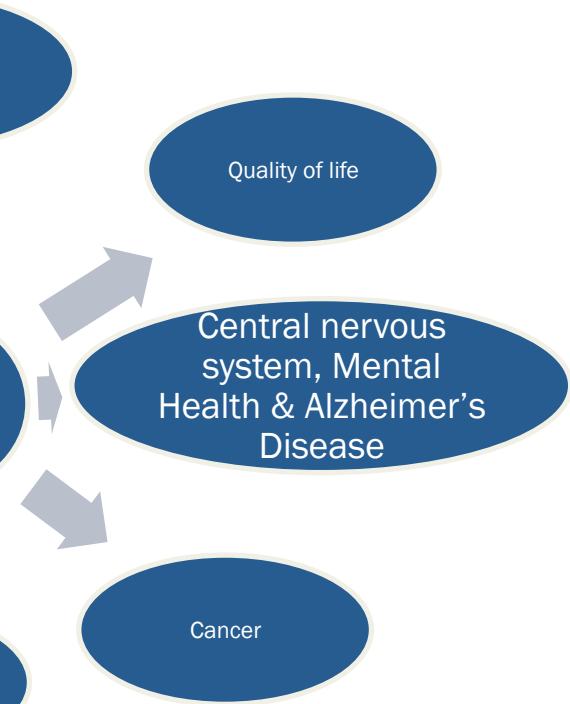
Studies have suggested that 9 hours or more sleep may represent a useful diagnostic tool for detecting unidentified undiagnosed morbidities

Sleeping 5 hours or less can be regarded as a higher risk group for cardiovascular mortality and morbidity

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Quality of life

Central nervous system, Mental Health & Alzheimer's Disease

Cancer

Studies have found that different forms of mental illness were much more commonly diagnosed in cohorts of sleep extremes with clinical depression and suicide being higher in individuals outside of the recommended sleep range

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Sleeping durations can be an indication of underlying psychological illness and a need for care

Quality of life

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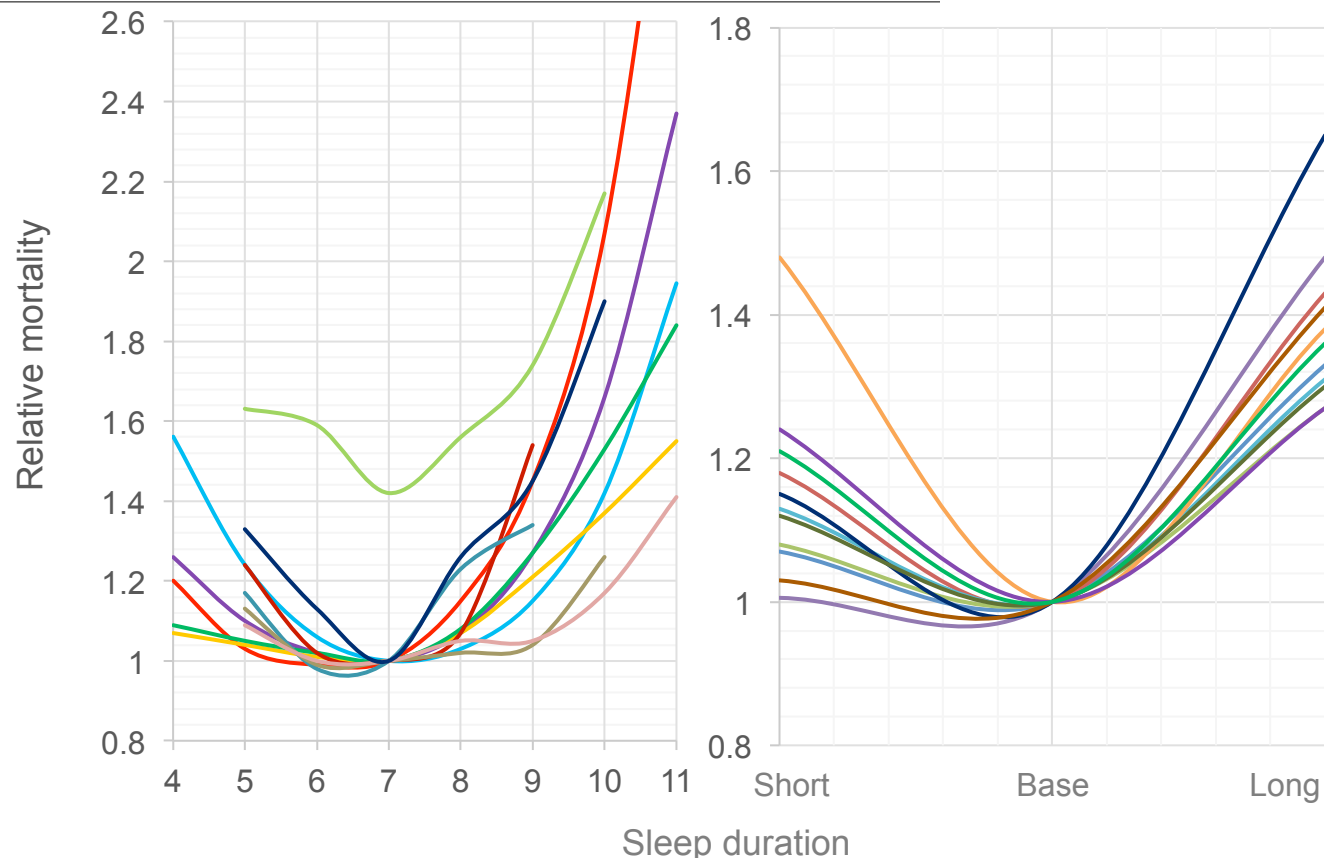
Sleeping durations can be an indication of underlying psychological illness and a need for care

Studies are being done in the measurement of REM sleep and electronic brainwaves leading to the prediction of Alzheimer's Disease years in advance

Sleep and Mortality
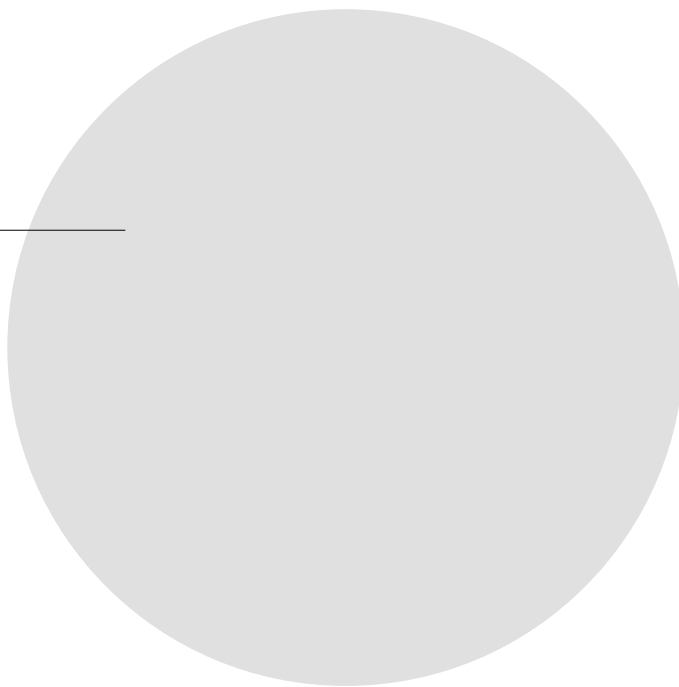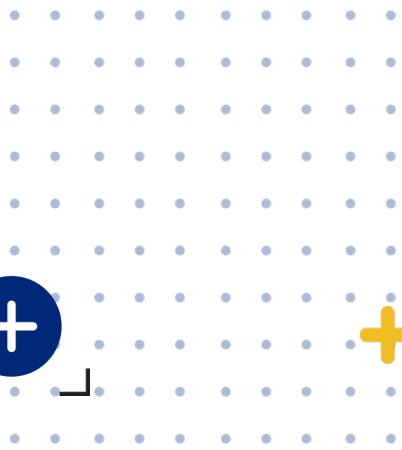
Relative mortality impact

The graphs represent the findings from 12 studies on the impact of poor sleep habits on mortality

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The less you sleep, the shorter your life will be

18 hours =

24 hours =

The less you sleep, the shorter your life will be

A study found that sleeping six hours per night increases your risk of having a car crash by 33% compared to sleeping seven or eight hours a night

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Sleeping less than seven hours a night increases your risk of death from all cases of mortality by 24%

Moving towards 7 to 8 hours of sleep per night will have health benefits, but long-term effects from long periods spent in the extreme sleep durations will remain

Mortality impact of long sleep

Both sides of 7 hours sleep either increasing the sleep per day or decreasing it will increase mortality and the risk of all illnesses

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9 hours or more sleep may represent a useful diagnostic tool for detecting unidentified undiagnosed morbidities

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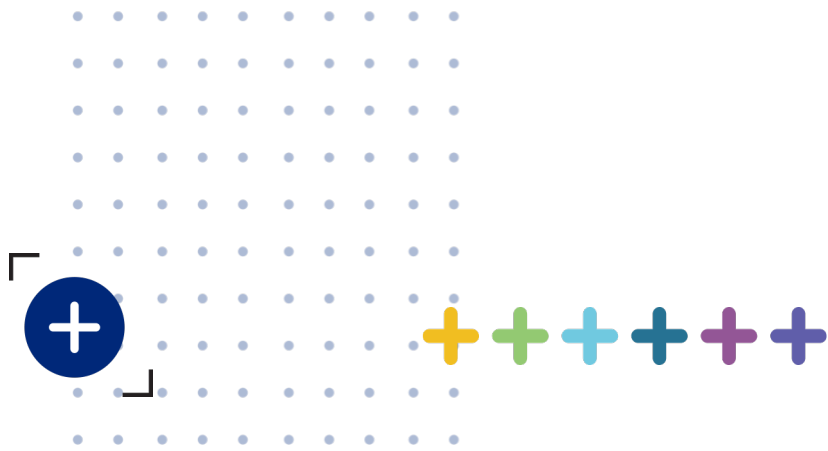
Key findings of literature review
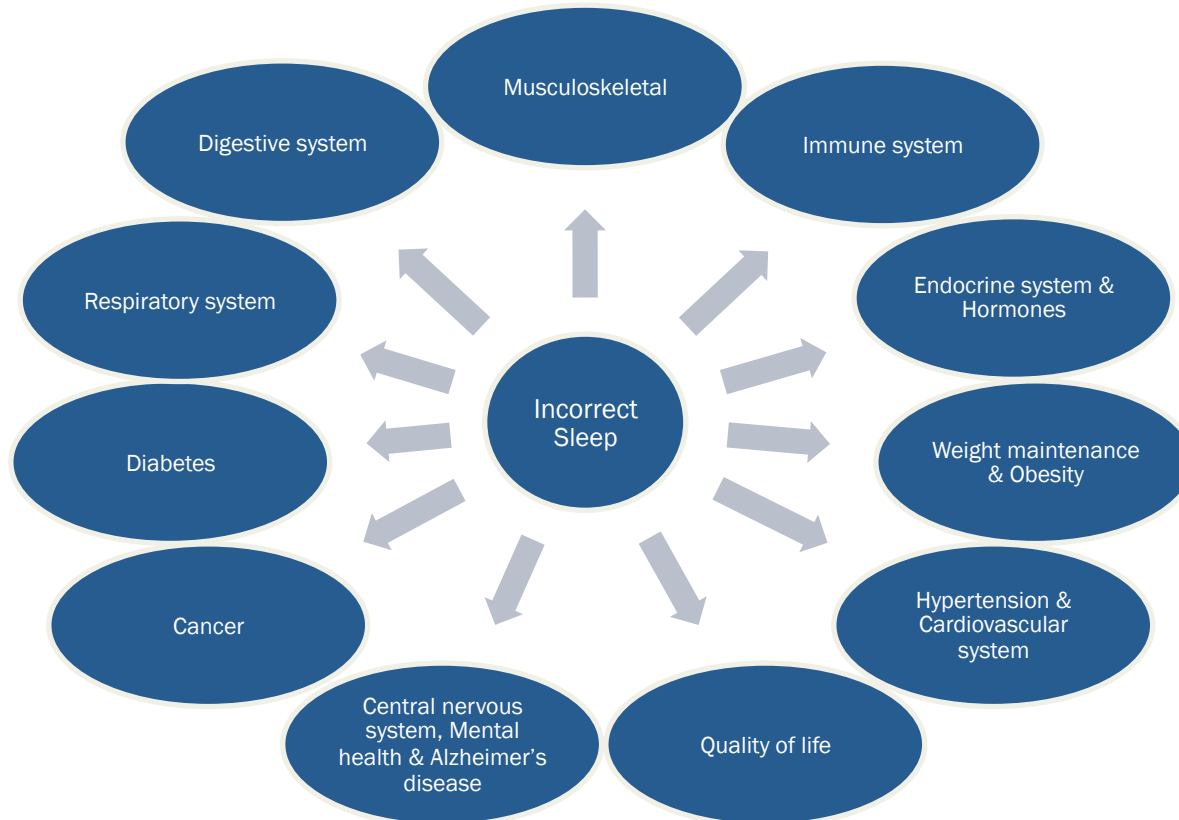
Irregular sleep linked to substantially poorer health outcomes – across all body systems

Clear circularity in the cause-and-effect triggers driving these outcomes

Direct link between poor sleep habits and increased mortality across extensive and varied studies

Sleep and Underwriting

Using sleep data in underwriting

Due to the notable impact of sleep on health, wellness and longevity we started on our journey to explore how sleep data can be used to improve the life insurance underwriting and risk management. The goals of the exploration are four-fold:

1 Determine how sleep data can be used to identify undiagnosed conditions not assessable by initial underwriting

2 Determine how sleep data can be used to provide early warning signs of the future onset of disease

3 Provide an indication of the severity and effective management of disclosed conditions

4 Identify trends in sleep data over time that can be used to trigger interventions to improve lifestyle wellness

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Exploratory research

Identifying techniques whereby sleep tracker data can be used in life insurance underwriting to generate observable outcomes to improve risk classification/management.

Topic not previously been explored in depth
Hypotheses are explored that are guided by related studies
Designed to allow open-ended and flexible (potentially qualitative) outcomes[1]

Provide the foundation analysis that will inform the inputs and techniques used when building the models that form the operationalized protocols

Good sleep, bad sleep

Before any analysis on the effect of bad sleep could be considered, we needed to define what measurable outcomes we... ...ad sleep. A literature review of 12 papers informed the following consensus quantitative and qualitative measurements of of sleep quality:[2-13]

	Good	Bad
Duration	7-9 hours for adults	< 6 hours, > 10 hours
Continuity	Sleeping straight through night (Max... ...)	> 1 wakeup
Timing	Regular bedtime/wakeup and enough time... ...ep phases	Misaligned circadian rhythm
Qualitative signs		Tired/irritable/lack focus, Needing naps in the day, Mood swings/depression

The number 8 and the word for 'night'...

French	huit	nuit
English	eight	night
German	acht	nacht
Spanish	ocho	noche
Portuguese	oito	noite
Italian	otto	notte
Dutch	acht	nacht
Swedish	aetta	natta
Romanian	opt	noapte
Walloon	ût	nut
Occitan	uèch	nuèch
Catalan	vuit	nit
Gascon	ueit	nueit
Picard	uit	nuit
Piedmontese	eut	neuit
Espéranto	ok	nokto

Trackers used to measure sleep

Polysomnography (PSG) is the best-practice for sleep studies that involves visual and audio monitoring as well as measuring brain waves and vitals. PSG is not a commercially viable for widespread sleep tracking. The question then remains - how do trackers compare to PSG? And how do the compare to one another?

Trackers vs PSG

18 out of 21 studies reviewed on this comparison show that by using their accelerometer and HR trackers provide strongly correlated results to those of PSG for the metrics they measure - with some overestimation of sleep duration and time spend in sleep phases.[14-35]

Intra-device reliability

5 out of 5 studies reviewed on the consistency of multiple of the same tracking devices equipped to the same subject showed no significant differences between the devices when investigated over any extended period. [36-40]

Inter-device reliability

All 32 studies reviewed on the consistency of different devices between showed wide variations between different wearable devices. The common device that presented among the most accurate was the Fitbit.
[41-74]

Consumer usage of sleep trackers

The usage of activity trackers in developed populations is on the rise and has increased to over 21% as of 2018 in the US. This trend is expected to grow substantially both in quantum and the sophistication of devices purchased.
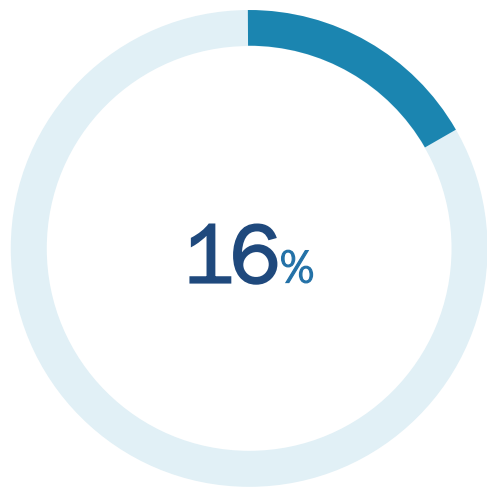
21%
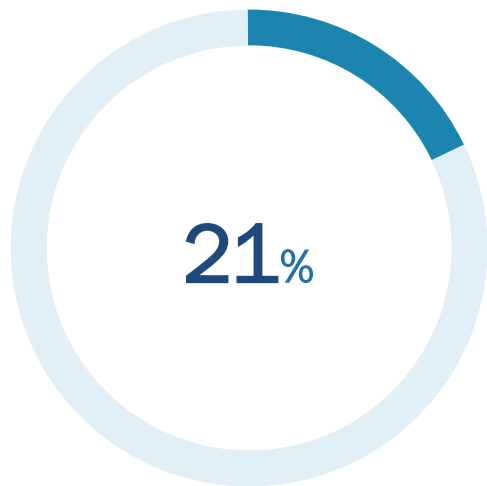
Regular usage of activity trackers (2019)

31%
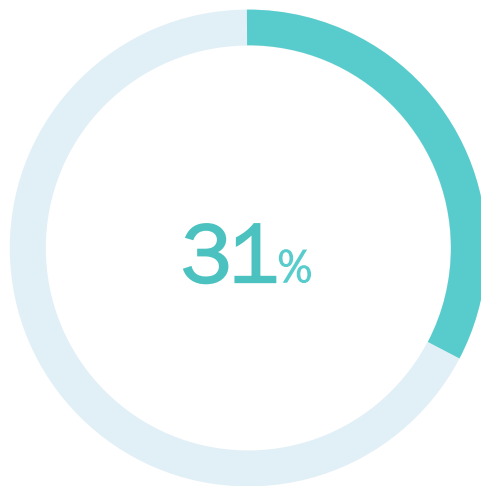
Usage of activity trackers amongst Highest SEC (2019)

Consumer usage of sleep trackers

The usage of trackers and apps to monitor sleep surveyed in 2017 observed that over 16% of people actively monitoring their sleep and an additional 45% of those survey were open to engaging in this practice.

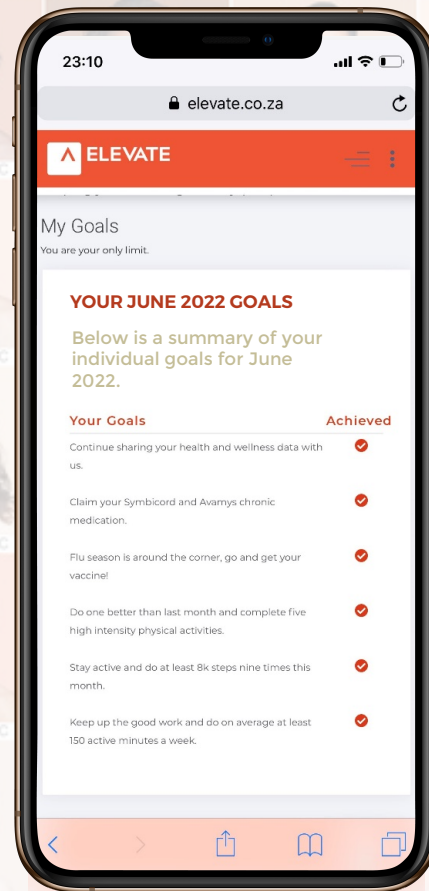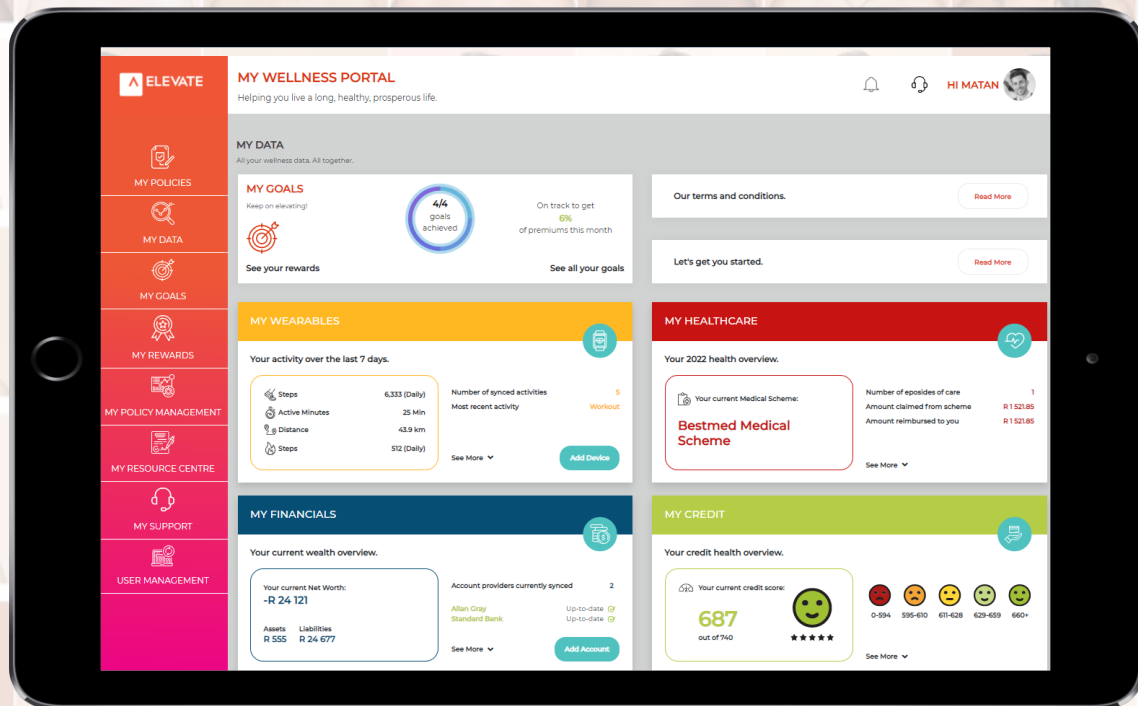**16**%

Regular usage of sleep trackers (2017)

45%
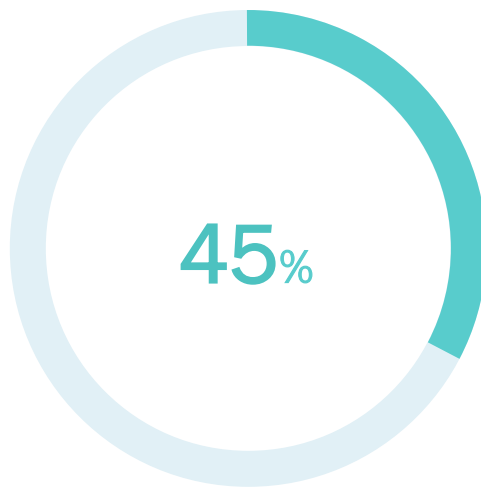
Open to using sleep trackers (2017)

Data collection & Methodology

- All data collected adheres to South Africa's POPIA legislation. ElevateMe Portal users consent to their data being used for benchmarking purposes. All data was fully anonymised so that policyholders could not be identified in any results of this study.

- All underwritten policyholders onboarded during the study period of 1 April 2021 to 31 March 2022.

- Limited to only those who had connected a Fitbit tracker to their ElevateMe Portal.

- Required continuous sleep data for period of 60 days – before and/or after underwriting.

- Enriched sleep data with all upfront underwriting information to determine all the disclosures that had impact on their premium and all other wellness data that was available for the policyholder from their ElevateMe Portal.

- Data profile built on each policyholder in final cohort explored using averages, std dev and daily trends for the study period and overlayed with their demographic information and underwriting disclosures.
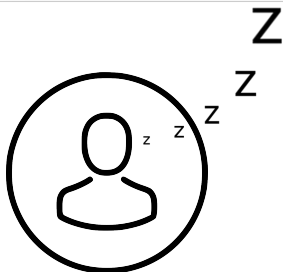
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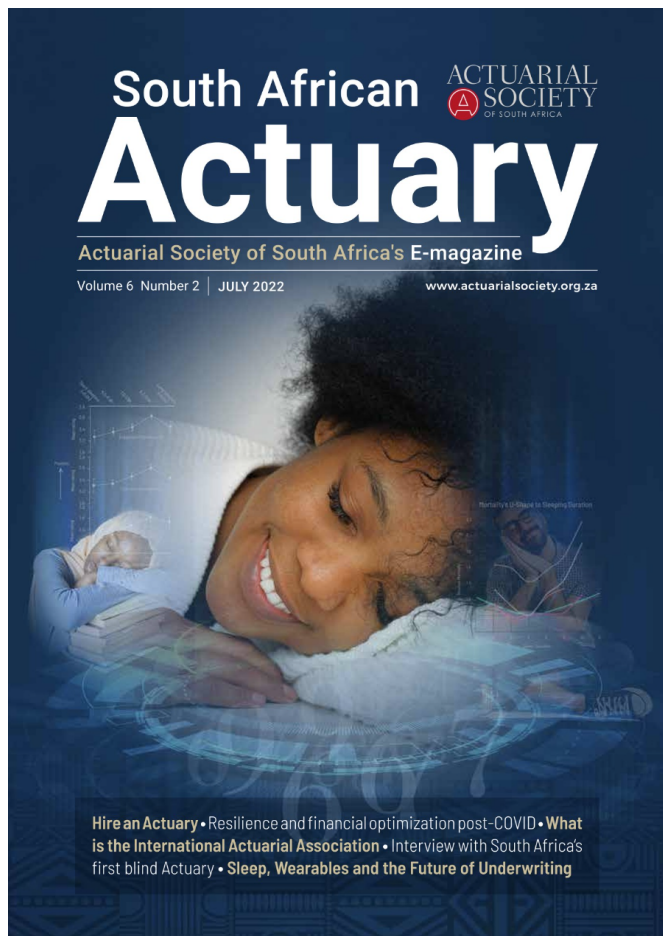
SA Actuary Magazine – Vol.6/No.2

For more information on
the data collection process
and methodology

https://online.fliphtml5.com/lgvk/avej/#p=49

Study findings: Policyholder 1

Policyholder_1

@policyholder_1

43 year old • Female

Non-smoker • Admin Manager

Underwritten on 4 October 2021

7.15 hrs
Avg sleep duration

1.24 hrs
Std dev sleep duration

19:15
Avg sleep start time

3.48 hrs
Std dev sleep start time

0.30
Avg wake ups

0.76
Std dev wake ups

Sleep study period: 5 October '21 – 31 March '22

**Acute Depression • Hypothyroidism**

Study findings: Policyholder 1 (Cont.)

Reviewing this policyholder's sleep metrics from the date of initial underwriting to the end of 2021 shows patterns that are very problematic for someone with a mental health disorder and give indications of poorly managed mental health.

Initial underwriting

Time Asleep (Hours)   No. of Wakeups   Bedtime
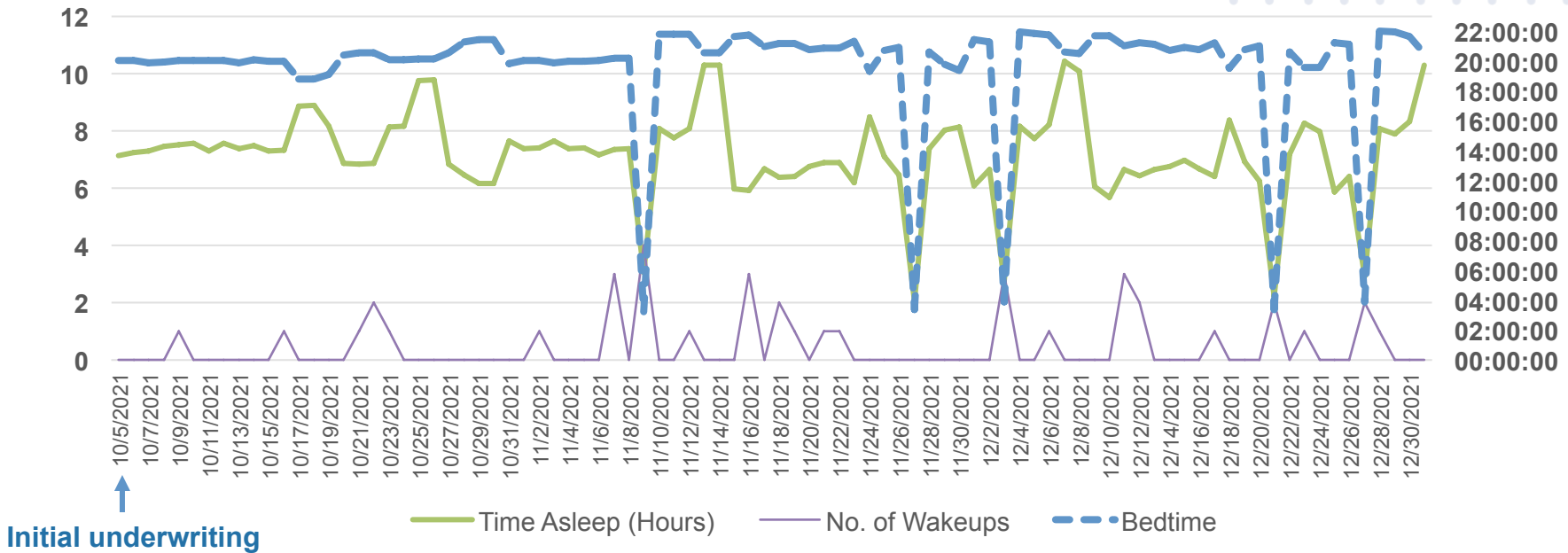
Study findings: Policyholder 1 (Cont.)

Looking at this same picture during the first three months of 2022 shows a stark change to the policyholder's sleep patterns. From February 2022 sleep patterns normalize considerably. But why?
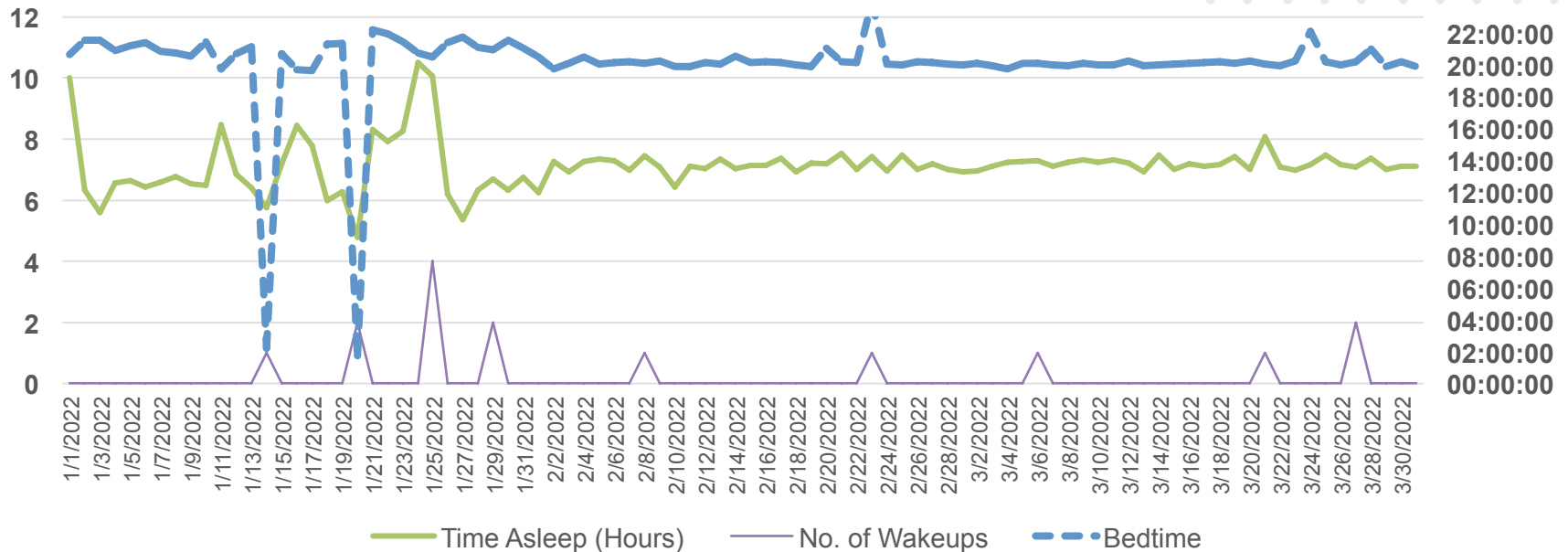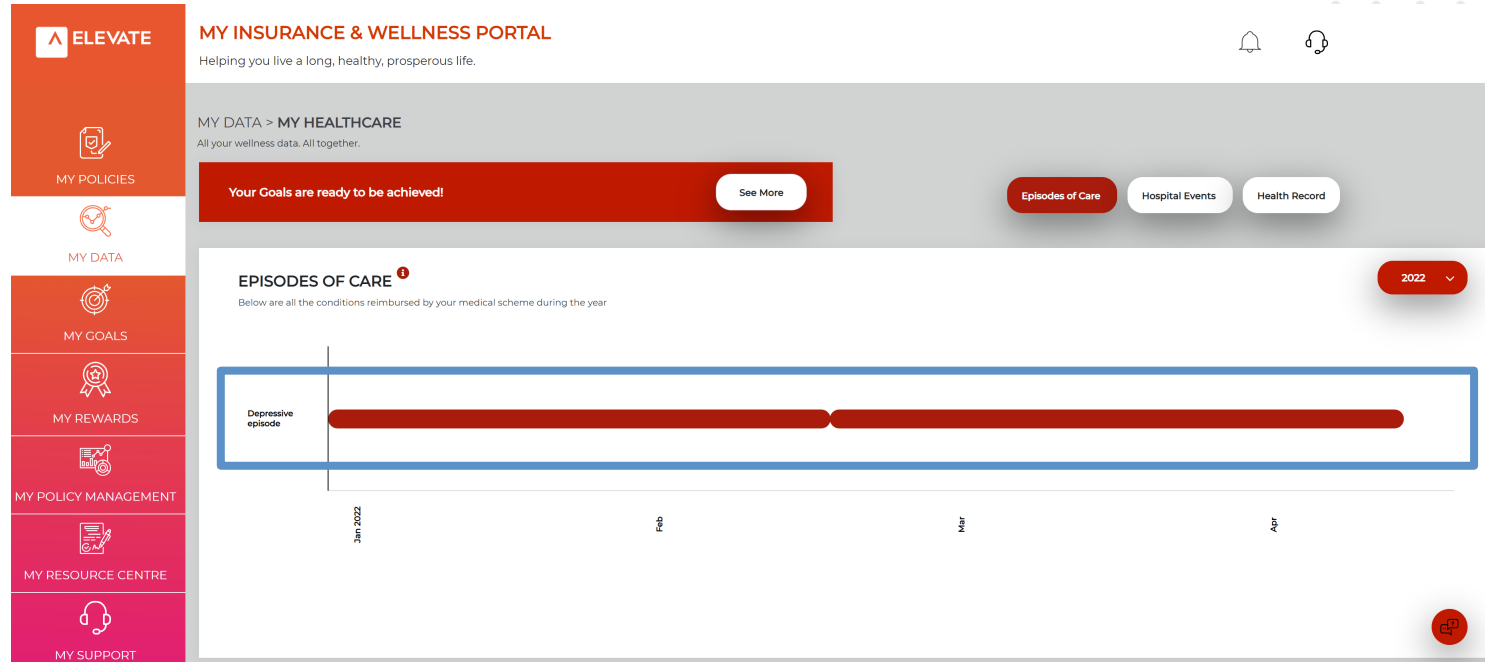
Study findings: Policyholder 1 (Cont.)

Reviewing the policyholder's health insurance data provides the context we need and shows that mental health treatment is sporadic in 2021.
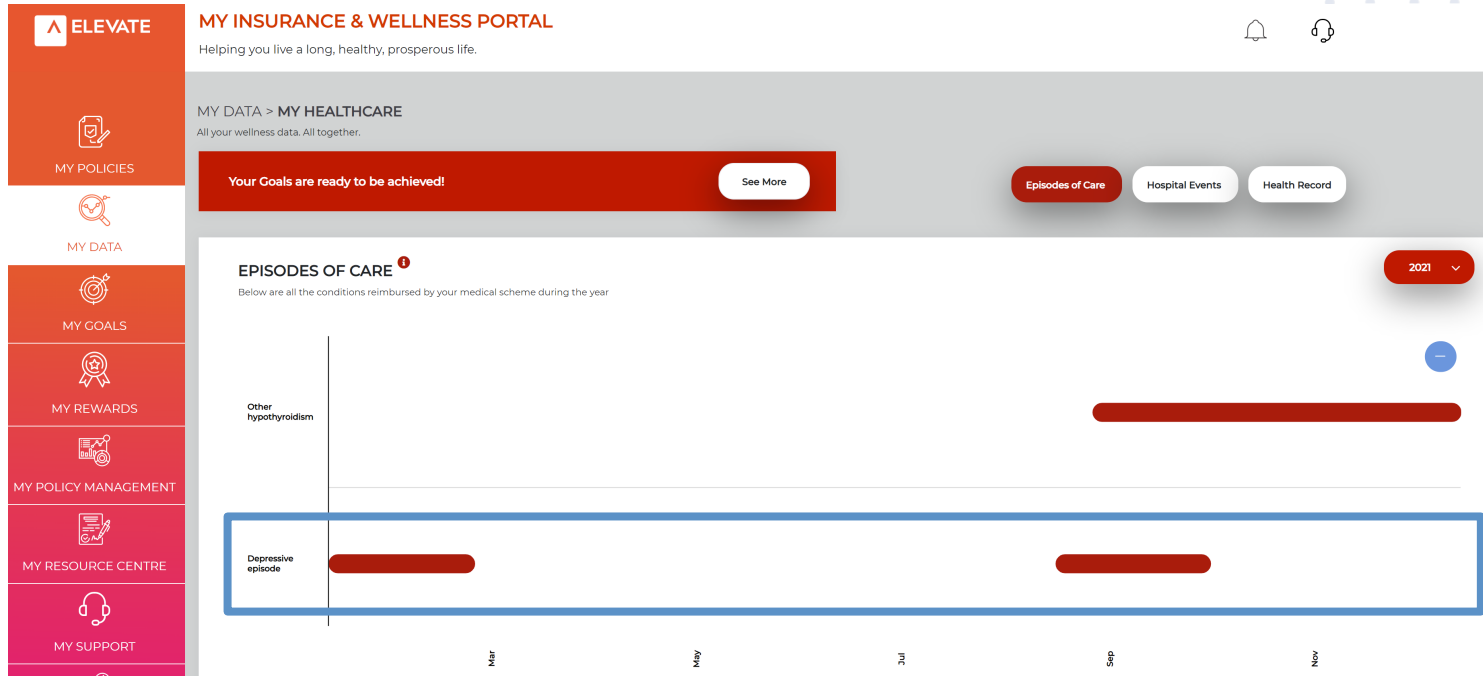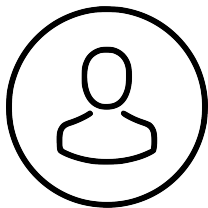
Study findings: Policyholder 1 (Cont.)

In contrast, in 2022 the policyholders is on consistent chronic treatment for their mental health disorder, which is directly aligned to the normalized sleep patterns.

Study findings: Policyholder 2

Policyholder_2

@policyholder_2

31 year old • Male

Smoker • Actuary

Underwritten on 7 September 2021

6.47 hrs
Avg sleep duration

31.51 min
Std dev sleep duration

21:51
Avg sleep start time

21.62 min
Std dev sleep start time

0.16
Avg wake ups

0.51
Std dev wake ups

Sleep study period: 6 August '21 – 31 March '22

Back Pain

Study findings: Policyholder 2 (Cont.)

Observation of this policyholder's sleep trends starting from a month before initial underwriting shows a marked change starting around the middle of December 2021. From this point up until the end of March 2022, the policyholder is sleeping markedly less (and more sporadically) and on average is getting to bed later.
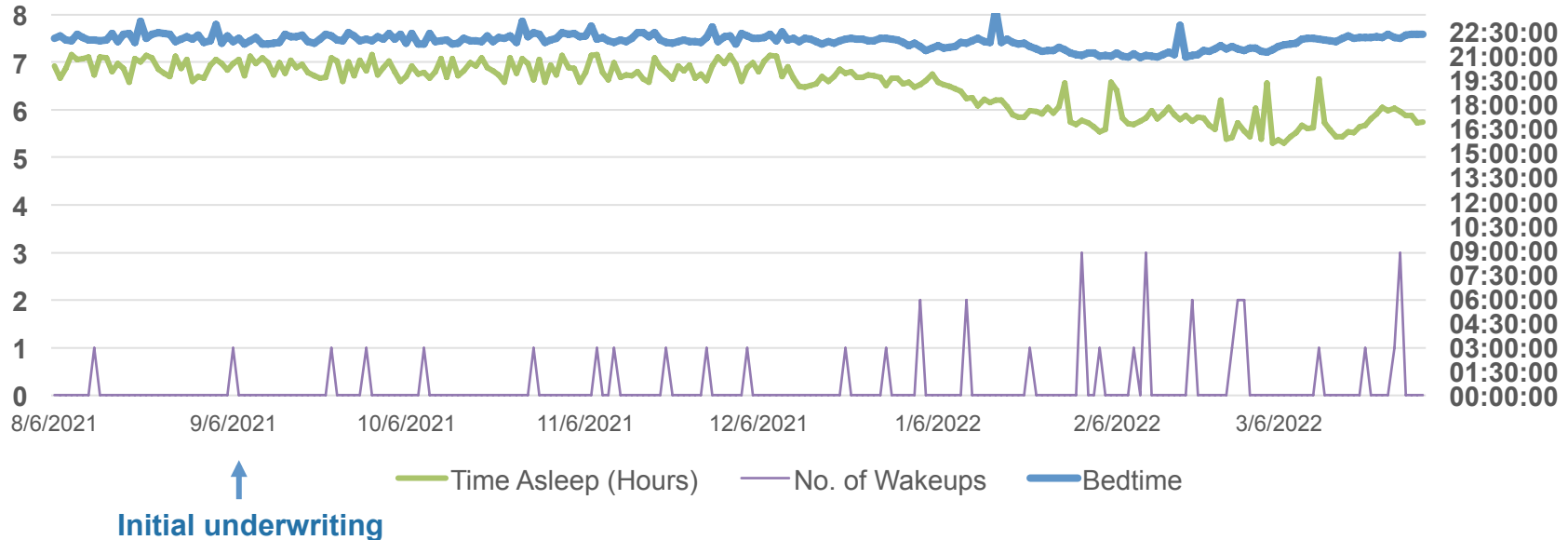
Study findings: Policyholder 2 (Cont.)

In this case, it is financial stress that is observed to be causing the change in sleep patterns. It can be seen below that during 2021 the policyholder's credit score is very good at over 650 (lowest risk category).
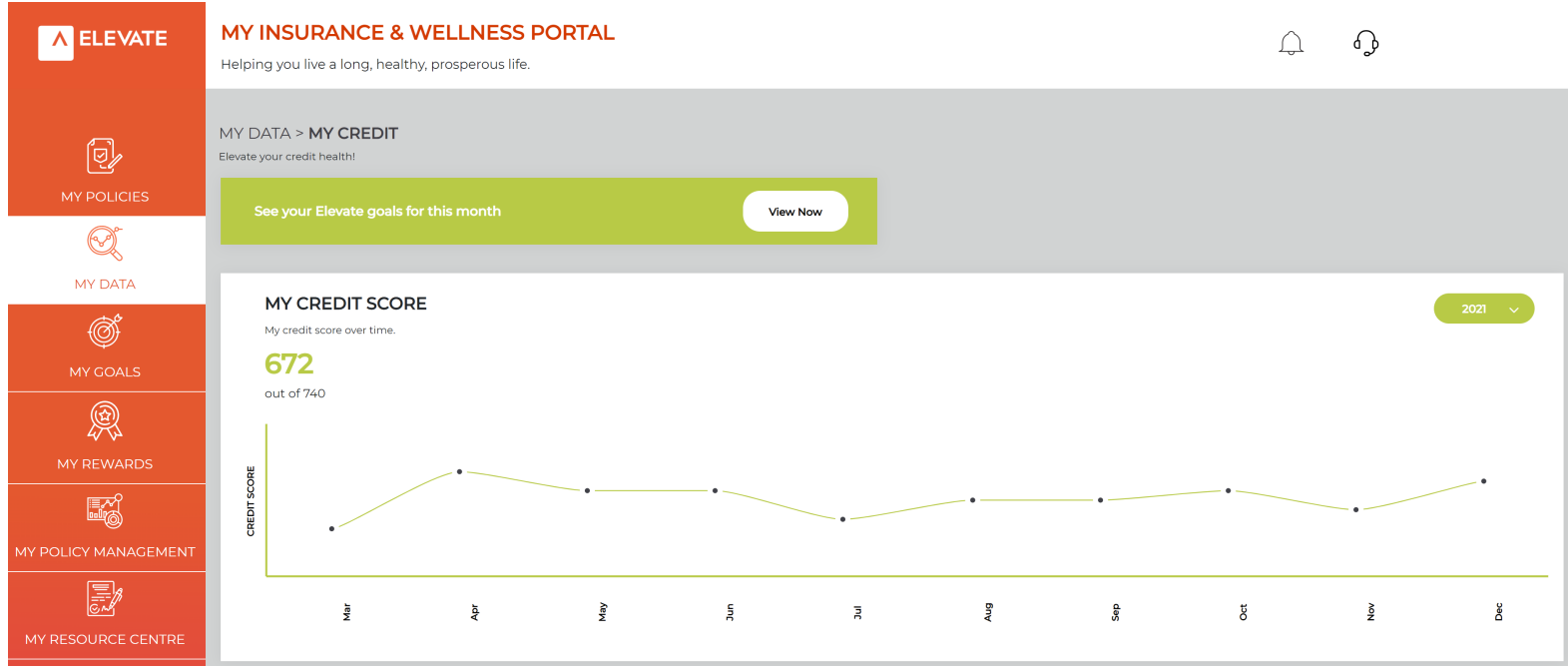
Study findings: Policyholder 2 (Cont.)

But in 2022 his credit score drops off sharply to below 625. Closer investigation points to the policyholder getting into arrears with some of his debt and accounts, using more of his available credit facility and requesting more credit from his banks.
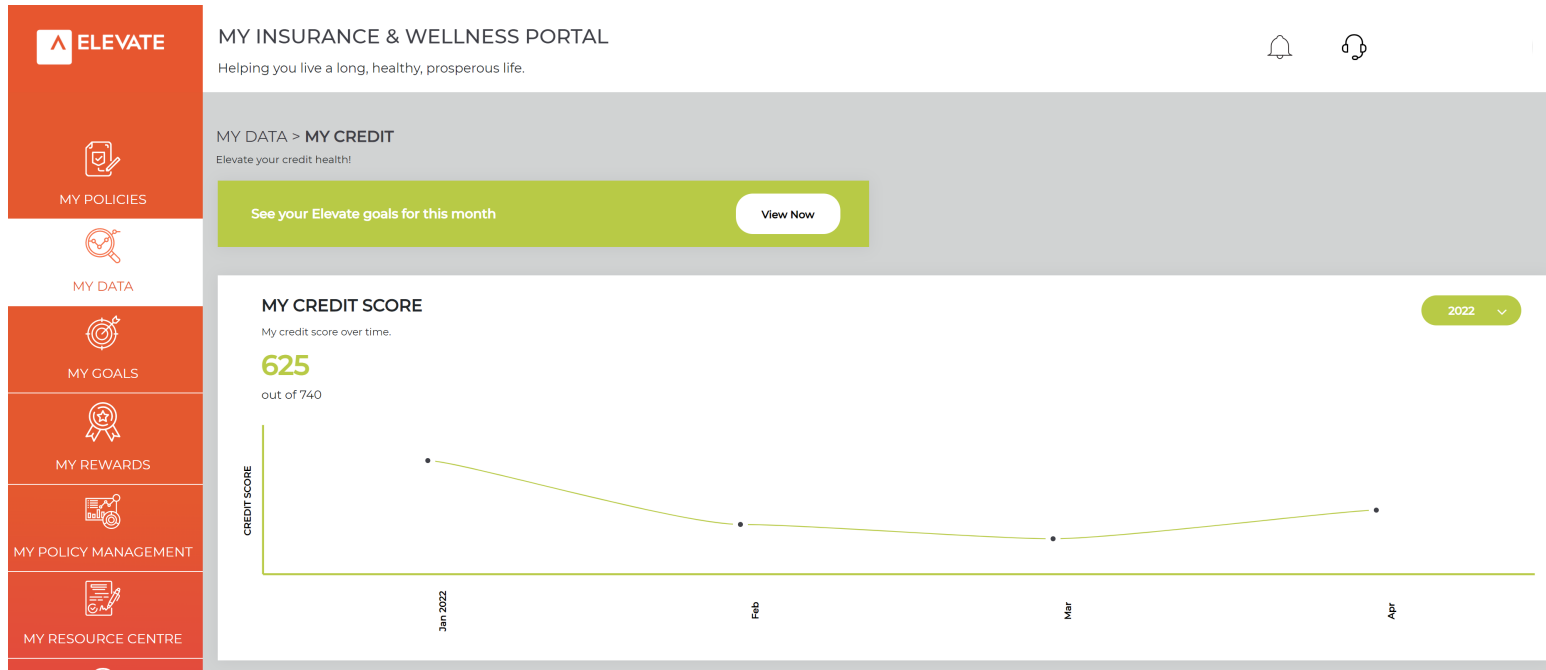
Where to from here?

Further exploration

Define protocols

Monitor and enhance

Expand the exploratory analysis to further identify trends and areas where incorporation of sleep data will be of greatest use

Codify and build the models which define the first set of underwriting protocols for the use of this new data in underwriting Elevate policies

Monitor and retrain the protocols/models in place to determine areas of refinement and the next set of protocols

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thank you