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Wearable technology

A health-and-care actuary's perspective

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Over[1] the last few years the world has seen wearable technology move from a possible future concept to a sizable segment of the technology industry [1, 2]. This growth is expected to continue, with some industry experts predicting its significant growth in the next five years [2, 3]. Currently, wearable technology falls into a wide range of categories based on function. These include: fashion, convenience, workplace productivity, and health and wellness. This diversity is not surprising in a young market still figuring out its identity. The most popular application of wearable technology to this point, however, has been in the area of health and wellness (predominantly comprising of fitness trackers and smartwatches) and this popularity is not expected to subside [4].

The success of wearable technology has changed the environment in which actuaries operate. Actuaries' thinking will need to evolve in order to take advantage of the opportunities that wearable technology present. This paper aims to assist with this by:

- providing a summary of the current (and potential future) capabilities of wearable technology;
- considering some actuarial applications to which these capabilities may be incorporated, and;
- forewarning of potential risks and challenges to be encountered on the journey of assimilating wearable technology into financial products and services.

Functions and capabilities

Health measurement

'Healthcare wearables' are those wearables that measure metrics that are assumed to provide an indication of an individual's health and state of wellbeing [5]. This is the category of wearable technology that is of most interest to a health-and-care actuary. Activity trackers and smartwatches are currently the most popular type of healthcare wearables [5]. These monitor metrics such as step count, active minutes, distance walked/run, kcal burned, sleep patterns, heart rate, workouts done, standing minutes, and steps climbed.

The capabilities of some healthcare wearables, however, go beyond the functionality of activity trackers and smartwatches. Recently there has been the emergence of wearables that are able to monitor detailed clinical metrics, such as blood pressure, heart function, glucose and insulin levels, medicine intake, and blood oxygenation levels [6]. Examples of such devices already available for purchase include the: iHealth blood pressure monitor[2], QardioCore and AliveCor EKG monitors[3,4], Medtronic insulin pump[5], and Proteus Discover[6].

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[2] https://ihealthlabs.com/blood-pressure-monitors/

[3] https://www.getqardio.com/qardiocore-wearable-ecg-ekg-monitor-iphone/

[4] https://www.alivecor.com/

These wearables go a step further than just measuring health, providing a tool to help manage conditions that beneficiaries are already known to have. For example, the iHealth blood pressure monitor syncs to smartphone devices and provides regular blood pressure readings recorded in a smartphone app. It allows individuals already diagnosed with hypertension to monitor the success of treatment aimed at controlling their blood pressure. In their current form, healthcare wearables of the type listed here are not comfortable to wear throughout the day. They do, however, represent the foundation upon which such technologies can be refined and developed in order to make them smaller, and more 'wearable'. Increased wearability provides the potential for such devices to become important tools in detection of the early onset of health conditions.

The future of wearables is exciting with new concepts for devices coming out at a rapid rate; boasting capabilities that provide faster, more convenient, continuous measurement and detection of life-threatening illnesses. A lot of these concepts may take many years to progress beyond concept phase to widespread consumption (and some may never do so). But they do provide an indication of the potential future capabilities that healthcare wearables may possess. And from the quantity, range and sophistication of concepts produced, the increased capabilities of healthcare wearables could be vast.

Data provision

Healthcare wearables can perform measurement of a wide range of health metrics. What this provides is data; which, properly interpreted, can paint a picture of the state of health and wellbeing of an individual on an ongoing basis. The key point here is the interpretation of the data from health metrics measured. The value of wearable data rests on being able to establish a quantifiable link between the metric measured and the health of an individual. For clinical metrics, this can be fairly straightforward given research already done. For example, normal glucose and blood pressure levels are well understood; as are the conditions that manifest as a result of significant and consistent divergence from normal levels. For physical activity and sleep metrics, however, quantifying the current status (and ongoing improvements or decline) of an individual's health can be more challenging. Research already done does point to a link [7]; however, the true nature of the link for a particular subpopulation will likely only fully unfold over time once a big enough volume of data is amassed and analysed.

Assisting with health management

A question that needs to be explored is: can wearable technology be leveraged to make people healthier? Healthcare wearables have the ability to provide information regarding an individual's health status, however, becoming healthier requires using the information provided to improve the health behaviours of individuals.

[5] https://www.medtronicdiabetes.co.za/our-innovation/Insulin-pump-therapy
[6] http://www.proteus.com/how-it-works/

One way that healthcare wearables can promote health behaviour improvement is through self-monitoring. This involves an individual engaging with their own health data. The information provided can be very motivational if what is discovered is accepted and the information used as the base upon which to improve. However, the information can be very destructive if used by individuals as evidence of how unhealthy they are and a reminder of their repeated failure to achieve their intended health goals. For self-monitoring to be effective, individuals need to maintain a positive mindset, remain detached from negative self-talk, and consider the full picture that the data provides [8, 9].

Self-monitoring is enabled by mobile-phone health interventions that have been designed around the information measured by wearable technology [10]. Examples of this are the mobile applications that accompany healthcare wearables. These can analyse the data to identify areas for improvement, provide education on how to achieve desired health goals, and gamification to increase engagement, as well as encouraging individuals to share their achievements with friends, compete and collaborate; providing further motivation to continue improving.

Healthcare wearables can also provide valuable information to healthcare providers to better care for patients. Such healthcare providers include general practitioners, specialists and allied health professionals (such as dieticians and physiotherapists). This information can be used to better diagnose, to better tailor treatment to patients, to maintain the ongoing success of treatment provided and to monitor patients [11]. Healthcare wearables can also be employed by hospitals in order to monitor patients' post-discharge metrics [12].

Self-monitoring may be subject to limited health behaviour improvements in the absence of proper interpretation of wearable data and guidance on the appropriate health behaviour changes to make. Self-monitoring can thus be greatly augmented through the involvement of healthcare providers.

Actuarial applications

Risk stratification and underwriting

Insurers use underwriting to evaluate and quantify the risk posed by potential policyholders. On the basis of an underwriting questionnaire (and possibly some medical tests) the majority of policyholders will be deemed to have risk levels appropriate for acceptance at standard rates. Those deemed to represent higher risk will undergo additional underwriting. A portion of these will be accepted on non-standard terms (such as additional waiting periods, cover exclusions, rated premiums or deferred cover). The remainder will be declined cover as they represent too high a risk, even on non-standard terms. Consequently, the outcome of a traditional underwriting process is a deep understanding of high-risk policyholders, and less so of the majority treated as 'standard' risks. Data from healthcare wearables can provide better risk stratification of the policyholders accepted at standard rates. In other words, incorporating the data from healthcare wearables into the initial underwriting process can

provide a more granular understanding of the risks and exposures of the pool of lives cover at standard rates. Policyholders can then be assigned more appropriate rates.

There is also the prospect that healthcare wearables can help insurers improve upon current resource intensive and costly initial underwriting practices. Access to the continuous picture of a policyholder's health status provided by healthcare wearables questions the value-add of an underwriting questionnaire and even many medical tests. This is particularly pertinent for low premium products where initial underwriting poses a significant expense. Incorporating data from healthcare wearables can help reduce inconvenience to policyholders and provide the potential for insurers to digitally streamline their underwriting process, reducing costs.

The value of this additional data does, however, differ depending on the insurance product with which it is used. For the pricing of private health insurance products this additional data may not provide much benefit. This is due to the short-term nature of these products and the fact that the policyholders' historical acute and day-to-day healthcare expenditure data may already be available from access to their electronic health records (likely providing more detailed information on their health status than that from healthcare wearables). The value of this data is also dependant on the regulatory environment. In South Africa, for example, private health insurance is community rated and cover may not be declined based on age or health status. In this case wearable data may be able to improve the estimate of the morbidity risk of the pool of lives covered, but insurers will not be able to take advantage of potentially improved premium rating.

For the pricing of life insurance products the information from healthcare wearables has potentially significant power. Traditionally life insurers collect information on policyholders at a single point in time during the initial underwriting process. Thereafter the quantification of mortality risk is passive. The data from healthcare wearables can provide detailed information on health metrics of policyholders on an ongoing basis. This provides the potential for substantial improvements in risk measurement through continuous dynamic underwriting of policyholders. This is not limited to pure life insurance products. Products such as dread-disease cover may similarly be able to achieve improved determination of morbidity risk.

These benefits do, however, rely on the assumption that the analysis and modelling of healthcare metrics are able to provide insights into policyholders' future mortality and morbidity risk. Such an assumption is not straightforward and is discussed further in the subsequent section.

Increasing insurability

Healthcare wearable data has the potential to be used to help increase the insurability of those potential policyholders determined high risks in the initial underwriting process. This is a by-product of healthcare wearables providing improved risk stratification and assistance in

better managing individuals' health. Such individuals are likely to be provided limited cover (or even excluded) because of having conditions such as diabetes, hypertension or being HIV positive. The presence of such conditions signals to the insurer that the individual has a high chance of premature mortality. In addition, the variability regarding the timing of these individuals' deaths is significantly increased, making the prediction of their mortality risk difficult. Such conditions are, however, manageable through appropriate treatment protocols. Therefore, insurance products can be designed that require high-risk policyholders to participate in a specific healthcare management programme in order to manage their area of increased risk. Participation would be a condition of cover, with lapsing from the programme resulting in reduced benefits or policy cancellation.

An example of an insurer who has embarked on such a product offering is All Life[7] in South Africa. They provide comprehensive life and disability insurance to individuals suffering from HIV and diabetes; conditional on their participation in their HIV Adherence Programme or Diabetes Control Protocol. All Life does not currently incorporate the use of healthcare wearables into their adherence or protocol definitions, but they could easily do so, in particular for diabetes. Healthcare wearables could provide data on policyholders, used to monitor programme participation and better assess the risk of these policyholders on a regular basis. Healthcare wearables may also help promote an overall healthier lifestyle, further reducing the mortality and morbidity risk of policyholders. The outcome of such a product offering is increasing cover for the same premium and providing cover where none was previously available. This meets the important need of increasing the market to which insurance cover is available and increasing the affordability of cover.

Product design innovation

Incorporated into product design, healthcare wearables can be used by actuaries to improve risk management, and help to better meet the needs of customers. A number of examples of innovative product design incorporating healthcare wearables are explored below.

Discovery Ltd. in South Africa is the county's largest healthcare funder; also having a sizable life insurance business. Discovery were one of the first companies anywhere in the world to employ wearable technology in their Vitality product[8]. Vitality is a lifestyle programme that incentivises members to live healthier lifestyles by providing them with rewards for achieving specified health goals. Rewards include discounts on travel, hotel accommodation, healthy foods, and leisure activities. Vitality allows members to connect their activity tracker or smartwatch to their profile in order for the data to be collected. Members then earn points and get rewards for achieving high enough activity levels as measured by these devices. While Vitality is a standalone product, you can only purchase it if you are covered by one of Discovery's other products. A significant portion of their health and life insurance business

[7] https://alllife.co.za/

[8] https://www.discovery.co.za/portal/individual/vitality-home

are therefore also members of Vitality. Vitality provides Discovery with the benefits of additional detailed data and improved health behaviour for these policyholders.

In essence, Vitality helps manage the mortality and morbidity risk of Discovery's health and life business by incentivising policyholders to improve their health behaviours. This is done by financially rewarding them for being healthier through discounted goods and services from reward partners. The measurement of policyholders' health improvements is being provided in large part by healthcare wearables. Lapse rates are also reduced on their products as policyholders persist in order to remain part of the lifestyle programme, to continue to receive Vitality rewards.

Another example of incentivising health behaviour improvement is by incorporating healthcare wearables into life insurance product design. Life insurers have achieved this by rewarding policyholders with premium discounts for exhibiting healthy behaviours. Improvement is incentivised by linking the size of the discount to policyholders' aggregate healthy-behaviour performance over the year. Examples of insurers providing such products are Momentum[9] in South Africa, Vitality Life[10] in the UK, and MLC[11] insurance in Australia. The calculation of the premium discounts varies among the different companies, but fundamentally the size of the discount is determined by the policyholders perceived health status. Again, this is determined in large part by the data collected from policyholders' healthcare wearables.

The incorporation of healthcare wearables in product design to incentivise healthy behaviour also has a risk selection effect. Such products are more likely to attract those individuals that are living healthy lifestyles and will thus benefit from the lifestyle programme rewards and premium discounts. This can provide a significant competitive advantage to the insurer by reducing the mortality and morbidity risk of their pool of lives covered.

Actuaries can also use the data from healthcare wearables to identify individuals that were initially accepted at standard rates but subsequently have come to have higher than expected mortality or morbidity risk. This could be as a result of poor health habits or the development of a chronic disease. Once identified these individuals can be incentivised to participate in health management programmes to actively support them in achieving a healthier lifestyle.

Related to the above, is the incorporation of healthcare wearables into health insurance managed care initiatives to improve the management of chronic diseases and recuperation from acute healthcare events. Such initiatives are planned to be rolled out by the NHS in the UK and various Health Maintenance Organisations (HMOs) in the US [13]. This is where healthcare wearables measuring detailed clinical metrics are likely required. A by-product of such initiatives is that not only cost efficiency increases, but also the quality of healthcare

[9] https://www.momentum.co.za/for/you/products/life
[10] https://www.pruprotect.co.uk/
[11] https://www.mlc.com.au/

provided. Patients are provided the most appropriate care; reducing wastage, increasing the speed of recuperation and reducing the chance of readmission.

Healthcare wearables are also being incorporated into insurance products to add value and better meet policyholder needs. Havensrock's[12] group income protection plan in the UK incorporates healthcare wearables to assist employers to maximise employee productivity. In this context, improved health is perceived to lead to increased employee productivity through less stress, improved cognitive ability, less fatigue and reduced absenteeism. As part of this product, each insured employee gets a free activity tracker and a free annual health check-up at their place of work. Data from activity trackers and health check-ups are combined on an online health portal that offers employees advice, annual reports, and notification of any health issues which should then be discussed with their doctor. Employers get an annual collated and anonymised report on the health status of their employees. Employees who become long-term sick get practical and emotional support tailored to their needs [14].

The incorporation of healthcare wearables into income protection cover therefore has the potential to benefit the employer, their employees and the insurer. Employers get healthier and more productive employees. Employees benefit from a healthier lifestyle and better management of their long-term sickness and injury. The insurer better meets the needs of insured employers and employees, and may see improved claims experience from less frequent, less severe and better managed long-term sickness and injury. Similar benefits can be envisioned for disability insurance products by incorporating healthcare wearables to help reduce the incidence of disability and increasing the pace at which temporarily disabled employees return to work.

It is worth noting that the applications discussed above illustrate the role played by wearable technology in the convergence of health and life insurance.

Risks and challenges

Developing rating factors for pricing

Incorporating wearable technology into product design and pricing is not without its challenges. A lot of analytical work is required to turn the data from healthcare wearables into meaningful rating factors to incorporate into estimates of morbidity and/or mortality rates. One approach is to model how the health metrics measured by wearables relate to variations in short and long-term prevalence of sickness and death. This is essentially undertaking the process of developing rating tables based on healthcare wearable data. Considerable research on the short and long-term determinants of mortality and morbidity has been done over many decades in order to assist in this process [15, 16]. In addition, clinical knowledge can be sought to relate the data on health metrics to changes in mortality

[12] http://www.havensrock.com/incomeprotection/

and morbidity rates. However, the effects of the health metrics on the determinants of health are generally studied and considered in isolation. For example, a study will be done on the effect of increased physical activity on longevity *all else equal*. Healthcare wearables are likely to measure multiple health behaviours simultaneously. Modelling the interactions can be very challenging given the collinearity between how these health metrics affect mortality and morbidity. Furthermore, determining the shape of the rating factors by, for example, age and gender can be equally demanding.

A preferred approach may be to collect wearable data over a period until there is sufficient experience to assess the effect of the introduction of healthcare wearables on a risk pool's mortality and morbidity rates. Rating factors can then be determined from own experience. The drawback of this approach is that it creates a deferred period between when wearables are employed and when the benefits are realised.

Healthcare wearables affect condition specific morbidity and mortality. In other words, healthcare wearables can affect conditions such as non-communicable diseases, obesity and poor sleeping habits. However, they do not affect other determinants of mortality and morbidity such as genetics and accidents. Consequently, mortality and morbidity rates should be split out into condition-specific and not-specific rates and the rating factors applied exclusively to the condition-specific rates.

Product design challenges

Issues arise with data that has been self-measured and inputted by an individual. This is common for recording nutritional information and other metrics that are not automatically captured by device sensors. There are ways of attempting to corroborate self-inputted data. For example, inputted nutrition data can be reconciled with healthy-food spend at grocery stores. However, if this cannot be effectively done it is difficult to trust the credibility of such data. This limits its usability for risk stratification and measurement as well as for the basis of rewarding individuals as part of product design.

Incorporating healthcare wearables into product design also poses the challenge of getting policyholders to opt-in to providing their wearable data and maintaining policyholder engagement with their devices [17]. Research shows that there is a high drop-off rate in the use of wearables after purchase [18]. If policyholders stop using their healthcare wearables (or use them intermittently) then the data collected will become scanty, reducing its credibility and reliability. Insurance products that incorporate healthcare wearables will likely incorporate initiatives to maintain policyholder's engagement with their devices and incentivise opt-in. Such initiatives include: providing devices to policyholders free of charge (or at a discount), financial incentives for continued use and a communication strategy publicising the lifestyle advantages of policyholders making continuous use of their devices [17].

Operational challenges

The information provided by wearable technology may not always be accurate. This could be a result of the quality of the technology itself. Poor materials or software could mean that the measurement of health metrics is not accurate. Tried-and-tested devices should be used to avoid this happening. The measurements by wearable technology are also open to manipulation. This is particularly a problem where individuals are rewarded financially for achieving health outcomes. An example of such manipulation is putting your wearable on your dog in order to increase your steps count. This issue can however be mitigated by considering multiple metrics measured by a device in tandem. For example, considering number of steps together with average heart rate. Such issues were experience by Discovery Vitality's Active Rewards[13] benefit in South Africa resulting in them recently overhauling their points allocation system [19].

There are also complexities surrounding the practicalities of the data collected from wearables. Examples included ensuring data privacy and effective data management initiatives. While these may not be unique to wearable technology, there are additional complexities that need to be considered. Examples of such complexities include successfully combining and standardising data from multiple wearable devices and ensuring data continuity as people change and upgrade their devices.

Wearable technology provides vast opportunity to enrich the insurance environment by providing actuaries with an additional dimension with which to innovate. Wearable technology is still in its infancy with the potential of presenting even further opportunities for actuaries. Insurers and funders have already started to incorporate wearable technology into their product offerings and it may one day become a staple in order to remain competitive in life and health insurance markets.

[13] https://www.discovery.co.za/portal/individual/active-rewards

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