

HARNESSING FUTURE TECHNOLOGY IN THE PREVENTION OF CHILDHOOD OBESITY* AND TYPE 2 DIABETES

PROJECT WORK RESEARCH REPORT

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BACKGROUND

WHAT IS 4IR?

Technology has played a major role in advancing most areas of our everyday lives but it is also transforming the world we live in.

The Fourth Industrial Revolution (4IR) or Industry 4.0 is the fusion of technologies of the physical, biological and digital spheres (The Columnist, 2017). It is thus different from the previous three industrial revolutions characterised mainly by advancements in technology (Schwab, 2018). Through 4IR, advances in communication and connectivity will lead to overall increase of efficiency. While previous industrial revolutions brought steam power, electricity and computing technology, the new technologies of their era, 4IR will use existing tools by connecting and integrating them in innovative ways. For businesses and manufacturers, this offers potential to increase efficiency and profitability by providing customised products and services for customers and allowing organisations to adapt to changing requirements over time (EY Global, 2018).

According to Satya Nadella, CEO of Microsoft, “The confluence of data with massive computational storage and cognitive power will transform industry and society at every level, creating opportunities that were once unimaginable from health and education to agriculture, manufacturing and services.” (Schwab, 2018).

No one knows for sure how 4IR will unfold but it will affect everyone, from all parts of the public and private sectors. As such, like all revolutions, it is expected to be disruptive. Many things that societies are built on will change. According to Professor Paolo Frizzi, it is “a revolution without boundaries, neither of nation, race, culture or gender, spreading across the world with incredible velocity.” (The Columnist, 2017).

Nonetheless, according to PwC (n.d.), “4IR is more than technology: as it gradually shapes how we live and work (and even play), it also ushers in a revolution of experience”. The

* For our project, we are looking at obesity caused by overeating, a diet high in simple carbohydrates as well as physical inactivity and not genetic related obesity.

way we buy and consume goods are changing through online platforms and customers of the future will demand more customised or personalised products. Indeed, 4IR is expected to change product delivery, customer interactions and expectations (Cotteleer and Sniderman, 2017).

According to an Ericsson report, wearable devices are expected to replace smartphones and Artificial Intelligence (AI) empowered smart assistant will become a vital part of life for the masses (Hyper island, 2018).

The immense data that comes with greater connectivity combined with AI's ability to analyse them could change how society operates by identifying problems which were previously unthought of by humans. As a result, 4IR will bring new opportunities for AI-human collaboration to improve lives, and help undo damages caused by the prior three industrial revolutions (EY Global, 2018) or even itself.

Challenges of 4IR

According to Schwab (2018), the benefits of 4IR have to be distributed fairly such that it is inclusive and accessible for all regardless of socio-economic status.

4IR should give humans more freedom and control over their lives and organisations should not only consider what is profitable financially. This way, humans can be empowered with technology and not determined by it. More importantly, we have to minimise probable harm 4IR may cause on vulnerable segments of society, the environment and future generations.

However, research pointed out that while executives theoretically understand the changes 4IR will bring, they face difficulty keeping up with technological changes and predicting what externalities new technologies could have (Deloitte, n.d.).

Another challenge of 4IR is the reluctance to change by stakeholders. Almost 50% of chief executives responding to PwC's annual survey (2017), expressed concerns that investors, employees and the public would distrust the concept.

With 4IR, routine tasks overtaken by robots may result in mass unemployment. Cisco and Oxford Economics (2018) reported that more Singaporean employees will lose their jobs than other ASEAN countries. While more jobs will be created because of the accompanying economic growth, our workforce is not ready for the new roles. While technologies like Uber generates over 50,000 jobs a month, they will soon be replaced by self-driving cars. Already Mercedes-Benz's first self-driving truck has taken off, and in the near future autonomous cargo vessels will sail our oceans (Jabber, 2017). In reports delivered at the World Economic Forum, India, South Africa and China may face "social upheavals and increased income inequality" in future due to increasing adoption of emerging technologies like AI.

By the year 2030, AI will change almost everything. Is it a change for the better or will AI threatened what it means to be human, to be productive and to have a free will? The world has heard the alarming predictions from some of the brightest minds about AI's potential impact on mankind. Tesla and SpaceX Chief Elon Musk worries that AI is much more dangerous than nuclear warfare (Clifford, 2018). The late scientist Stephen Hawking warned that AI could become the "worst event in the history of our civilisation" if humanity is not prepared for its possible risks (CNBC, 2017). In the WEF Global Risks Report 2017 experts view AI, biotechnologies, geoengineering and the Internet of Things (IoT) as particularly

worrying (Schwab, 2018). Fears about AI are likely to require new legal regulations and some form of human control to counter public fears about machine decision-making.

In the WEF Global Risks Report 2018, it was highlighted that cybersecurity threatens all things digital. As such, another key challenge of 4IR is to have in place regulations and solutions to promote innovative and confident use of technology (Schwab, 2018). Privacy protection also demands updated regulations pertaining to protection of individual information or intellectual property rights (EY Global, 2018).

OUR COMMUNITY OF CHOICE AND RATIONALE

OBESITY AND DIABETES: A PROJECTION

Diabetes is a worldwide epidemic and severe health concern in Singapore as we have the second highest diabetes prevalence among developed nations, with almost one in nine being diabetic. The number of Singapore residents with diabetes is expected to hit a million by 2050, if nothing is done to control this trend (Mahmud, 2018). While diabetes is not deadly, it can lead to other more serious diseases and disabilities. There are increased chances that more Singaporeans will suffer from diabetes or need to look after someone who is diabetic (Seah, 2019).

The global cost of treating diabetes is set to double to almost S\$3 trillion (US\$2.12 trillion) by 2030 compared with that in 2015 which is at 1.8% of the world's gross domestic product (GDP). However, if further preventive measures are not taken, the global cost is likely to rise even higher to US\$2.45 trillion or about 2.2% of global GDP (Kurohi, 2018). In Singapore, the cost burden of diabetes is set to rise from \$940 million in 2014 to 1.8 billion in 2050 (HealthHub, n.d.). This is just the cost of treating diabetes patients as the true cost is greater. The disease burdens society and economy as it threatens life span, productivity and economic competitiveness (Kurohi, 2018).

Obesity is a leading cause of diabetes, which Prime Minister Lee Hsien Loong called a "health crisis" in his 2017 National Day Rally speech (ChannelNewsAsia, 2017). The World Health Organisation (WHO) predicts that by 2030, diabetes is expected to more than double in Singapore as obesity rates continue to rise (Food Industry Asia, 2016). Indeed, obesity poses extraordinary challenge not just to public healthcare sector but to every person as no one is immune to it. Obesity is a result of surplus energy intake from overeating and insufficient energy burnt from physical activity (Foo et al, 2013). The reduction of physical work, the advent of mechanical transportation, an increasingly sedentary lifestyle and the convenience to high calorie food have brought obesity levels to new heights (Hruby and Hu, 2015). Malaysia, Indonesia, Singapore and Thailand are among the most overweight countries in South-east Asia and this obesity cost to the Asia-Pacific region is S\$218 billion a year (Today Online, 2018)

The term 'obesogenic environment' is used to describe an environment that promotes obesity by encouraging people to eat unhealthily and not do enough exercise. This is a result of society becoming more affluent, buildings becoming equipped with elevators and lifts, public places being dominated by shops selling calorie-dense food (BBC News, 2014).

WHY ARE WE FOCUSING ON PRIMARY SCHOOL CHILDREN?

The number of obese adults in Singapore have dropped by 3.9% in 2017 but the number of obese children has increased by around 2% (Lee, 2018). As such, it is importance to inculcate healthy habits in our young. According to World Health Organisation (2014), obese

children are also more susceptible to health problems when they become adults, such as cardiovascular disease, insulin resistance, musculoskeletal disorders and some cancers.

According to Khalik (2016), obesity in school children has risen and will push up the rate of diabetes in Singapore, already among the highest in the developed world. To make things worse, EIU research indicates that childhood obesity rate is growing faster in Singapore than in Japan, the UK and USA (Food Industry Asia, 2016). Among school-going children, the prevalence of obesity increased from 1.4% in 1976 to 12.7% in 2006 for primary 1 students and 2.2% in 1976 to 15.9% in 2006 for primary 6 students. The National University Hospital's (NUH) division of paediatric endocrinology has seen a 130% increase in patients who are children with weight issues from 2013 to 2017 (Young Parents, 2019). Indeed, one third of Singapore's young face diabetes now and rate is projected to double by 2030 (Whitehead, 2016). That means that by the year 2030, approximately 66% of Singapore's young will be diabetic.

A study released by Duke-NUS Graduate Medical School Singapore and at the Duke Global Health Institute revealed that the lifetime medical costs for an obese child is S\$24,000 more than a normal weight child (Teo, 2014). Indeed, the rise in childhood obesity is a huge burden for individuals, families, society and healthcare systems in the years to come (Hruby and Hu, 2015). While not all overweight children become overweight adults, obesity in adulthood often start from childhood (Lee, 2018). A Health Promotion Board (HPB) study found that 7 in 10 children who are overweight will remain overweight as adults (FIA Communications, 2017). Obesity also increases the incidence of psychological issues in children such as low self-esteem and depression (Sabina, 2018)

Government regulations mandates all pre-schools meet requirements on serving a variety of food groups during meals, cutting out sugary drinks and deep-fried food. For full-day pre-schools, a minimum of an hour of physical activity with at least half of this time spent outdoors daily is required (TODAY Online, 2017). There is, however, no such mandate for primary schools.

Prevention is key in the case of obesity (Hruby and Hu, 2015). In addition, it is believed that "if (we) could get rid of obesity, diabetes rates would fall to about a third or maybe a quarter" (Hickey, 2014). As such, our objective is to promote a healthier lifestyle by harnessing future technology for the prevention of obesity and Type 2 diabetes in primary school children (6-12) in Singapore. For this project, we are looking at obesity caused by overeating, a diet high in simple carbohydrates as well as physical inactivity and not genetic related obesity.

With 4IR, the increased connectivity, the advancement of AI, robotics and machines doing things for us, will our future environment be even more obesogenic? How do we minimise this potential risk and harm 4IR may cause on our future generation suffering from its unintended health consequences.

COMMUNITY INVESTIGATIONS

SURVEY

A full scale survey was conducted with 209 respondents of which 78% or 163 respondents are parents with primary school children (6-12). Only responses from the latter group are included in our analysis so that it is representative of our target population. Details of the survey analysis can be found in Annex A.

SITE INTERVIEW

A site interview with Dr Lee Hee Hoon, Director, Allied Health & Community Operations and Ms Jesslyn Chong, dietitian in charge of JurongHealth Food Log app was conducted at Ng Teng Fong Hospital to find out more about the challenges faced in the prevention of childhood obesity and type 2 diabetes and the AI enabled app that is on trial with pre-diabetics at the hospital. A summary of the interview is attached in Annex B.

FUTURE TREND ANALYSIS

THE FIVE CHALLENGES

Challenge 1: Since 49.7% of parents do not have accurate knowledge regarding their children's dietary needs and would rather depend on their own knowledge than AI to set a limit on their children's daily sugar intake, primary school children are at substantial risk of childhood obesity and type 2 diabetes.

With 4IR, the possibility of using new technology to prevent childhood obesity and diabetes becomes a possibility. According to Albert Bourla, COO of Pfizer USA, "AI, medical devices, biological sensors, digitization of healthcare records are all supercharging discovery capabilities right now and we will be able to develop solutions for medical needs that today are very difficult to solve" (World Economic Forum, 2018). Indeed, according to Schwab (2018), AI's most urgent application is in healthcare.

From our survey, only 50.3% of parents managed to answer the question "What do you think is the maximum amount of sugar your child can consume a day in order to remain healthy?" correctly. This is an indication that approximately half of the parents do not have accurate knowledge on daily dietary and health needs of their children. As such, parents on their own, might not be able to make the best dietary and health decision for their child.

Parents play a significant role in preventing childhood obesity. High sugar intake is associated with an increased risk of obesity. Parents are gatekeepers of their children dietary intake and such knowledge is essential to regulating sugar consumption (Dallacker et al, 2018). In our survey, out of 49.7% of parents who failed to answer the question correctly, 12.3% felt that the maximum sugar intake was 10 teaspoons, which is 4 teaspoons more than recommended. According to Dallacker et al (2018), parents significantly underestimated sugar content of most foods and beverages (F&B). For instance, 92% of parents underestimated sugar content of yogurt by seven sugar cubes. As such, while they care about what their children consume on a daily basis, the challenge exists as many parents are unable to make the best dietary and health decisions for their child.

MRI scans have shown that sugar stimulates the same parts of the brain as cocaine and scientists believe this makes sugar highly addictive. In addition, one can of soda provides more sugar than what a child needs for 24 hours. While some parents think that it is healthier to exchange soda for apple juice, some store bought juices have more added sugar than soda (The Asian Parent, n.d.) This emphasises the fact that many parents are in fact ignorant of the maximum sugar intake for children per day, underestimate the sugar in F&B and as such may not be the best decision maker in this process.

Indeed, research has shown that some children become obese because their parents do not know how to choose or prepare healthy foods (Roth, 2016). According to WebMD (n.d.), many parents still have the misconception that sugar causes children to have more energy.

Parents are sceptical of AI making decisions for them. In our survey, 76.7% of parents would rather depend on their own knowledge than AI to set a limit on their child's daily sugar intake. One of the key challenges of 4IR is whether stakeholders are reluctant to change and if they are willing to embrace new technology (Schwab, 2018). Even when parents are given a choice to make a decision on their own based on AI's recommendations, 22.7% of parents surveyed still wanted to decide entirely on their own.

This is not surprising as a study revealed that most people are confused about and are reluctant to embrace AI. In a study, 72% of respondents expressed some sort of trepidation about AI (NewsGram, 2017). Indeed, according to Polonski (2018), "Many decisions in our lives require a good forecast and AI agents are almost always better at forecasting than their human counterparts. Yet for all these technological advances, we still seem to deeply lack confidence in AI predictions. Recent cases show that people don't like relying on AI and prefer to trust human experts, even if these experts are wrong."

With parents not having accurate knowledge of their children's dietary needs and their scepticism towards the use of AI to help make such decisions, primary school children are at substantial risk of childhood obesity and type 2 diabetes.

Challenge 2: Since 72% of primary school children do not have enough daily exercise and the trend of a sedentary lifestyle is expected to escalate in future with robots and AI doing more for children, giving them more free time for sedentary gameplay which AI, VR and AR have made even more addictive, primary school children are at substantial risk of childhood obesity and type 2 diabetes.

Our survey showed that 67.5% of parents with primary school children (6-12) have children who exercised less than 60 mins per day. To make matters worse, 4.9% do not exercise at all. This meant that in total, 72.4% of these children exercised less than an hour a day. Hence, one can conclude that majority of children in Singapore are not exercising enough and this sedentary lifestyle has long been linked to childhood obesity and type 2 diabetes.

While 4IR will result in many advanced technologies making our lives easier, many of these will also make us lazier. This is because new technologies are helping people to reduce the amount of physical activity and energy spent on accomplishing many tasks daily (Ivanova, 2016). Indeed, 4IR has been criticised for causing humans to move less. Given that more robots and AI will be doing things for us in the future, it is likely that we will have a more sedentary lifestyle (Chong, 2019). With the advancement of technology, children are for instance now commuting to school rather than walking compared to previous generations (SingHealth, 2018). As AI, intelligent robots and self-driving cars become the norm, we will live in an increasingly digitally connected world where our daily life and social interactions are technology based. As a result, we will be moving less (GMI Summit, 2019) and there will be less opportunity for incidental exercise. As such, the trend of an increasing sedentary lifestyle is expected to escalate in the future.

With 4IR and the convergence of AI, virtual reality (VR) or augmented reality (AR), this problem could be worsened in future as digital toys for children escalates their sedentary lifestyle. Hence, many children in the future would spend much time staring at a screen, refusing to move as there is no need to do so. In the future when AI and robot do more things for us and give us more free time, how will children spend the extra time? Will they be motivated to exercise? Most children with extra time will most likely play even more sedentary video games (Chong, 2019).

Evidence suggests that physical inactivity is a major cause of childhood obesity (Gupta et al, 2010). The American Heart Association recommended at least an hour of physical activity a day for children ages 6-17. The 1.5 hours per week of Physical Education in school is way below this requirement. To make matters worse, the National Sports Participation Survey (2011) revealed that 55% of parents with children below 12 indicated that their children did not do any sports outside school (See, 2015).

The recommended screen time for primary school children is not more than 2 hours per day. One of the major causes of a sedentary lifestyle is that instead of playing games outdoors, Singapore children spend more time in front of the television or computer (Lee, 2018). When children spend too much time indoors with their devices rather than going out to play, they lose precious exercise time. In our survey, only 11% of parents indicated that his or her children do not engage in on-screen activities such as gaming and entertainment.

Singapore is one of the highest consumers of electronics in the world and many leading foreign video game companies have established their base in Singapore (Gupta et al, 2010). DQ Institute found that Singaporean 8 to 12-year-olds spend on average 35 hours a week screen time for entertainment alone, three hours above the global average. This number increases further when screen time for homework are included (Kwang, 2018). In a 2017 study, 12 year-old Singaporeans' screen time is more than 6½ hours daily (Yang, 2017). While TV and computers used to be the only digital screens, the advent of mobile devices has made it easy for children to indulge in more screen time anywhere. In fact, children watching videos or playing games on a mobile device are common sights on public transport and restaurants. Our site interview also revealed that the availability of individualised devices has led to a sedentary lifestyle. There is also a lack of motivation to exercise and this is becoming habitual (Lee, 2019). A decrease in physical activity does not simply mean that less calories are being burned, metabolic rate is affected as well (Active Health, 2019). According to scientists from University of Montreal, an extra hour of screen time that a toddler has each week adds to their waist size by the time they turn 10 (Winterman, 2012).

According to Douetteau (n.d.), increasingly AI are used in content platforms and “are getting very adept at knowing what we like, and the more we use them, the better they deliver even more of what we like. Free games might let you win, then lose, then win, up until the tipping point where you are sufficiently engaged to rope you—or, more likely, your offspring—into in-app purchases for add-ons”.

As such, the trend of a sedentary lifestyle is expected to escalate in future with robots and AI doing more for children, giving them more free time for sedentary gameplay which AI, VR and AR have made even more addictive. As such, primary school children are at substantial risk of childhood obesity and type 2 diabetes.

Challenge 3: Given the proliferation of cheap, fast and convenience food, future enhancement in their delivery technology coupled with mass unemployment caused by 4IR puts primary school children at substantial risk of eating cheap, unhealthy food thereby increasing their risk of childhood obesity and type 2 diabetes.

From our site interview at Ng Teng Fong hospital, we learnt that the proliferation of fast and convenience food has been a significant contributor to the increase in obesity and type 2 diabetes (Chong, 2019). Changes in the F&B Industry where fresh food are replaced by cheaper but unhealthy mass-manufactured and preserved products as well as food becoming easily available have led to the decrease in incidental exercise and the increase in obesity and type 2 diabetes (Chong, 2019).

According to Bauman et al (2019), “the lack of success in childhood obesity prevention is often underpinned by the erroneous conceptualisation of the problem as a failure of the individual rather than as a normal response to an ‘obesogenic’ environment in which people must make an increasing effort to eat small portions of healthy foods and to engage in daily physical activity”.

This problem might worsen in the future as the accessibility and fast-paced delivery of various junk food is propelled by the convergence and advancement of technologies. Already, fast food companies such as McDonald's have changed how customers interact with them. With ordering kiosks installed and mobile delivery in place, customers are expected to see less human workers (Kline, 2018). Indeed, with 4IR, routine jobs at fast food restaurants are expected to be replaced by AI and robotics (Timberlake, 2018). In fact, it is believed that McDonald's will be run 100% by computers and robots (Russell, n.d.) According to its CEO, McDonald's strategy is to attract customers demanding convenience in an increasingly fast-paced world (Taylor, 2017). With 4IR, delivery may be performed by autonomous drones making it even more speedy and convenient for consumers.

Robotic technology will disrupt the future of vending machines. Future vending machine will be intelligent and connected, allowing prompt replenishment of those food items most in demand quickly thereby increasing the consumption of food high in salt content and the over consumption of food leading to a unhealthy lifestyle. Future vending machines will come in the form of automated entertainment robots that serve food to customers while dancing, playing music and animated displays. This enhances the customer experience especially for kids, pushing sale of convenience food to a new heights (Anderson, 2018)

According to Lim & Neo (2019), Singaporeans' appetite for fast food has helped the sector grow 29% when the entire F&B industry saw a 10% fall in sales from 2000 to 2018. This is despite the increase in national awareness of the need to eat healthily. In a Nielsen survey, respondents cited convenience or accessibility (58%), food taste (50%) and low price (48%) as the top reasons for purchasing fast food. Many students have also taken to eating convenience food near their schools due to the increase of convenience stores nearby (Lim, 2018). Convenience Store Cheers reported 10% year-on-year growth in sales of its ready-to-eat meals (Chia, 2017).

According to Nielsen survey, 44% of Singaporeans have purchased food deliveries online, higher than the global average of 33%. The study also found that 76% respondents preferred to patronise fast food restaurants (Nielsen, 2018). The revenue in Singapore's online food delivery industry is expected to increase to US\$164 million in 2018, up 27.9% from 2017, with around 1.1 million users, according to Hamburg-based market research firm Statista and by 2022, this number will increase at an annual rate of 17.9% to hit US\$316 million (Woo, 2018). With increased efficiency and faster delivery of services, parents are less likely to cook at home and will have no problem getting these food delivered to them fast without leaving the house and at the press of a button. In a survey on eating patterns in children in Singapore, 19% of respondents ate out five to seven times a week. The two most common reasons given for this were “convenience” and “nobody prepares home-cooked meals” (Ang & Foo, 2002).

Many students are turning to vending machines and ready-to-eat meals sold at convenience stores (Lim, 2018). The variety of food offerings are enhanced as consumers can now buy items like seafood hor fun, salted egg yolk pasta and even popiah from a vending machine. However, the accessibility of these new enhanced meals might cause overeating as well

as increase the risk of obesity. Dietitians warned that consuming ready-to-eat meals on a regular basis is unhealthy due to higher salt content (Chia, 2017).

With robots and AI taking over millions of routine jobs in the future, the likelihood of unemployment may rise. As parents struggle to make ends meet, the nutritional quality of food they can afford to feed their kids might be compromised. Many as a result may turn to fast or convenience food as it is a cheap option. Already low-income Singaporeans face the challenge to eat healthy. The National Health Survey 2010 revealed that households with income less than S\$2,000 a month had the highest prevalence of obese individuals (Kotwani, 2016).

As such, given the proliferation of cheap, fast and convenience food, future enhancement in their delivery technology coupled with mass unemployment caused by 4IR puts primary school children at substantial risk of overeating cheap, unhealthy food and increasing their risk of childhood obesity and type 2 diabetes.

Challenge 4: Since 82.7% of primary school children do not listen to parents all the time when it comes to what they should or should not eat, AI and virtual reality enhanced marketing and advertising put children at substantial risk of choosing and overeating unhealthy food and beverages, putting them at substantial risk of childhood obesity and type 2 diabetes.

From our survey of parents of primary school children (6-12), a significant majority (82.7%) of children do not listen to their parents' advice on what they should or should not consume all the time even though majority (77.9%) of the parents tried to educate them on obesity and/ or diabetes once a month or more. This is in line with research that showed parents of primary school children do not know what their kids consume in school or have no control over what they consume (Gonzales, 2016).

According to research, children prefer junk food over home-cooked food because of powerful marketing strategies of the industry. Children who easily identified logos of brands such as Kentucky Fried Chicken, McDonald's and Coca-Cola were more likely to prefer food by these companies (NDTV, 2018). Changes in the global food systems have resulted in a shift from individual to mass preparation, reducing the time and price of food consumption. This has led to more highly processed food and their effective marketing are all contributing to obesity. In fact, the marketing of F&B is found to be particularly effective among children (Gortmaker et al, 2011).

A Harvard University study indicates that food advertisements can increase snacking habits by 45% (Active Health, 2019). When children view food advertisements or when TV programmes feature food products, they are lured to overeat.

4IR is changing the face of marketing and advertising, making children more susceptible to their messaging. AI will allow advertising to become personalised and adaptable, appealing to the specific person's needs and desires while virtual reality may make it possible for children to interact and smell the food being advertised, motivating them to make a purchase and to consume, making overeating a norm. According to the Straits Times (2017), in future AI will be used to give personalised recommendations, chatbots will assist brands by being part of online social conversations while virtual glasses will allow the product to engage and interact with potential buyers.

The Singapore Government has imposed restriction on food advertisement targeted at children on television and print media (HPB, n. d). Even though fourteen F&B companies agreed to reduce advertising aimed at children, there is already an exodus of audience from traditional media to new media platforms. Indeed, Associate Professor Lee Chun Wah do not think it will have a lasting impact as "Children are increasingly exposed to advertisements on social media such as Facebook and YouTube - all these bypass parental overview" (The Straits Times, 2012). As such, this policy on unhealthy food advertising targeted at children is unlikely to be effective. To make matters worse, by 2020 total internet advertising revenue in Singapore is expected to reach US\$616 million, making internet advertising growth in Singapore higher than the equivalent global rate (Pandey, 2016).

Our site interview at Ng Teng Fong hospital further reinforces this as Chong (2019) shared that parents definitely play a huge role in the prevention of childhood obesity and type 2 diabetes. However, they seem to be failing in this role because the strength of the influence coming from the food industry is far too strong on the media.

As parents are not always around when children are purchasing food and children do not listen to their advices on what to consume all the time, AI and virtual reality enhanced marketing and advertising put children at risk of choosing and overeating unhealthy food and beverages, putting them at substantial risk of childhood obesity and type 2 diabetes.

Challenge 5: Since parents are sceptical of new technology and feel that the privacy and security of personal data is paramount, they may not use future preventive technology available on their children, therefore their primary school children may be at substantial risk of developing childhood obesity and type 2 diabetes.

It is predicted that 10% of the world's population will be wearing clothes connected to the internet by 2022 (Thompson, 2015). The first implantable mobile phone may become commercially available in 2025 allowing accurate tracking of a person's health while they communicate thoughts through brain waves or signal (Thompson, 2015). Light Field Displays may project 4D images directly onto users' retinas from a point of focus (Moradi and Lin, 2017) and miniature chip size version of medical grade wearable device with ability to scan for bodily changes such as lactic acid level, cholesterol level, glucose level may also become available (World Economic Forum, 2018). Researchers also reported the development of an ultra-thin, flexible biosensor that could be incorporated into contact lenses or on the backs of watches for real-time glucose tracking using sweat or tears (ACS Nano, 2018).

These technological advances could greatly increase our preventive healthcare capabilities and potentially reduce the cost, morbidity and mortality burden of obesity and diabetes. According to Rajeev Suri, President and Chief Executive Officer, Nokia Corporation "Future technology will empower citizens to take an active role in managing their own health and that of their children. The healthcare industry will also experience the transition from reactive care to continuous monitoring and preventive care." (World Economic Forum, 2018).

While more advanced preventive technology will be available in future, our research showed that parents prefer the least invasive devices and also those they are most familiar with. 50.9% of parents chose wrist wearables as the technology they are most willing to use. 17.2% chose mobile applications while 11% chose a non-invasive bio-sensor. Only about 2% chose microchip implant which is considered more advanced but more invasive. Only about 2% chose Internet connected clothes which though are non-invasive but is a new technology parents are not familiar with. Indeed, according to Rajeev Suri, President and

Chief Executive Officer, Nokia Corporation “Obviously, if you can stop pricking yourself or use a non-invasive device, people will obviously go for that option simply because they are non-invasive to begin with.” (World Economic Forum, 2018). Getting humans to get their own microchip implants has so far been a tough sell (CBN News, 2018).

One of the questions posed at World Economic Forum discussion on “Transforming Health in the Fourth Industrial Revolution” was that even if we create the best drug or the best wearable technology, there is no guarantee that users will take the drug or wear the device (World Economic Forum, 2018). In order for a better solution, it is important for us to consider community’s views in order to ensure that a majority of the community will be willing to make use of our end-product (Glinos, 2018).

With 4IR, technology will have the ability to collect more data regarding individuals’ health and other factors of their daily routine and life. Protecting this data is pertinent and it will be detrimental if this data falls into the hands of people with ill intent. With technology developing rapidly, more data can be stored in a single database and this increases the possibility of database hacks.

The recent surge in the number of cyberattacks in Singapore such as the SingHealth cyberattacks where hackers gained access to many people's medical records has raised public scrutiny on the collection of data in Singapore and how well they are protected. Although measures have been put in place, such as SingHealth imposing a temporary Internet surfing separation on all of its 28,000 staff's work computers (The Straits Times, 2019), these measures may not be enough to counter further cyberattacks. In fact, these measures in turn make future technology hard to be linked to the health databases and electronic health records. As our site interview revealed, in Ng Teng Fong General Hospital and other public healthcare institution, there is Data-Internet separation. This means that all of the hospital’s databases are all not connected to the internet. This is due to security reasons, to prevent hackers from mining the databases (Chong, 2019). However, this Data-Internet separation also meant that future technology is very hard to put in place in the hospital because most of this technology happens to be internet-oriented.

The SingHealth cyberattack occurred due to blunders by employees and weaknesses in the system. The breach into the public healthcare group’s database could have been avoided although the attacker was adept (Choo, 2019). With SingHealth’s largest data breach in July 2018 and the breach in the Health Ministry’s HIV Registry revealed only 2 years after it happened (Chan, 2019), it is not surprising that stakeholder’s trust in new technology is low. This is particularly so when parents are most concerned for their children’s security and safety. Even in our survey, parents highlighted that safety is imperative in motivating them to use the new technology. Indeed, they mentioned that “Security and privacy (needed to be) ensured (as) there are so much issue with information leaks.”

As such, since parents are sceptical of new technology and feel that the privacy and security of personal data is paramount, they may not use future preventive technology available on their children, therefore their primary school children may be at substantial risk of developing childhood obesity and type 2 diabetes.

UNDERLYING PROBLEM

(Incorporating Challenges 2, 3 and 4)

Given that with 4IR, robots, VR and AI will enhance the marketing and delivery of fast food and sedentary video games to children thereby increasing consumption and physical inactivity leading to unhealthy weight gain and 66% of Singapore's young being diabetic by 2030 (Condition), how might we harness future technology to help primary school children maintain a healthy Body Mass Index (BMI*) (Key Verb Phrase) so that they can lead healthier lives (Purpose) in Singapore from 2027 and beyond?

THE FIVE SOLUTIONS

Solution 1: *WRIST Fit*, a health wearable programme

The Ministry of Health (MOH) will work with the industry (e.g. XiaoMi, Garmin, FitBit) to create a health wrist wearable which MOH can use to implement *WRIST Fit*, a health wrist wearable programme in collaboration with schools.

WRIST Fit not only acts as a payment, transit-link and identity device but can track students' exercise level, dietary intake and health status such as blood sugar and obesity threat level. It also measures physical activity of children and prompts them to meet their minimum step count. The objective is to make moving fun so that more kids enjoy being active. Gamification is used to encourage the increase in physical activity.

WRIST Fit would be distributed to all primary school students through the schools but can be used anywhere. *WRIST Fit* is capable of showing data through its interactive screen. To encourage physical activity, the element of a leader board, bonus points, rewards, level, badges and guilds will be introduced. Users can also customise the *WRIST Fit* through colour selection and can also create an upgradable avatar of themselves. The mobile mode will also allow adding friends, joining guilds and the setting of daily physical activity objectives.

Using AI, the IoT and real time monitoring, recommendations will be sent to parents and students on how to improve on the user's diet and exercise routines. Quantum Cryptography which will become more accessible and affordable in future will be used to ensure security and prevent data breaches. Activated by face recognition, the device will only work on the specific student and not others, it will be weatherproof and can only be removed by parent or guardian.

Parents will receive notifications when the user has not been exercising regularly or has been consuming too much unhealthy food. Parents can also choose to set a limit to the consumption of certain food groups such as fast food, convenient food or sugar sweetened drinks and make adjustments to the limit based on AI recommendation. The payment for such food groups will not be approved once the limit has been reached. Not only does the health wrist wearable help to promote healthy living, it can also help to provide motivation for students to lead such a lifestyle through friendly peer competition. With the rise of 4IR, these health wrist wearables will be connected to the internet through 5G, allowing real time health and dietary data to be measured and analysed by AI.

For parents, their children's health status can then be used to determine credit amount to offset medical bills or annual cash rebate, the option being selected by parents. This is a

* In Singapore, the BMI (weight for height chart) is the most commonly used tool to determine obesity (Lee, 2018).

useful incentive as a healthy family means less reliance on the health system and lower burden on government health expenditure. The incentive will also motivate parents to use the system to monitor their kids.

Schools would also have access to selected information so as to give awards as incentives for primary school children to exercise more and eat healthier food.

WRIST Fit allow parents to monitor and control the child's dietary consumption level, and used peer motivation and gamification to encourage the amount of physical activity carried out by the children, therefore the children will be able to maintain a healthy BMI so that they can lead healthier lives. Research has shown that both the threat of parental monitoring and actual parental monitoring lowered the number of non-nutritious foods chosen and total caloric content of the meal chosen by kids (Klesges et al, 1991). The long term objective is to inculcate good eating habits and exercise into children's daily routine so that these become part and parcel of their lifestyle. It is essential that the development of healthy habits begin from young and are sustained through adulthood and everyone play their part (SingHealth, 2018).

The Children's Health and Monitoring Programme (CHAMP) in Manchester, England collects annual BMI of primary school children and offers feedback to parents through a secured website. Research showed that children whose parents registered with the website recorded a decrease in their BMI while children whose parents did not register with the website recorded an increase in their BMI. These findings indicate that monitoring through digital intervention could encourage positive lifestyle change as parents reported making lifestyle changes within their family to improve children's health directly in response to feedback about their children's BMI (Dam et al, 2019). Features such as self-monitoring, goal setting, feedback, social challenges and competition as well as rewards all aid in weight control. (Forman et al, 2016)

Research also suggests that wrist wearable will produce the desired results of increased physical activity in children when they are worn correctly, are adequately engaging, and when they are designed in a feasible manner that is appealing to children. For instance, devices that children are able to customize, wear comfortably, used for any occasion, and are fun/engaging to use (Sabina, 2018). According to Kraft (2019), in the future these sensing technologies will be central to disease prevention, diagnosis, and therapy.

In addition, studies suggest that the presence of healthy eating peers can influence healthier food selection and that positive friendship experiences foster engagement in physical activity (Salvy and Bowker, 2014)

MOH could start working with Fitbit, Garmin or other companies which are already working on future wrist wearables for chronic disease prevention. Together, they can look into testing in selected schools and full roll out by 2027. Subsequently, every batch of primary one students will be assigned these wrist wearables.

Solution 2: Exergames

The Economic Development Board (EDB) will provide incentives for game companies to develop new Exergames on every potential platform such as smart phones, virtual glasses and mixed reality.

Exergames refer to video games that encourage physical activity, such as Pokemon Go. Mixed reality, the merging of real and virtual worlds to produce new environments and

visualizations where physical and digital objects co-exist and interact in real time, is expected to be the gaming platform of the future. Exergames on currently available platforms (smartphones) and those of the future (mixed reality) will be able to attract children who are already playing sedentary games. Mixed Reality combines the best points of virtual and augmented realities as users can easily transition through the real and virtual world simultaneously. Mixed realities also allow holographic images, which means primary school students can talk and play games with friends in a hologram or even be a character in their favourite movie during exergame play.

These companies that are developing or working on such exergames will receive partial funding or tax incentives from the government in that area of work. This will help to allow new exergames to flourish and dominate the gaming industry. With such government incentives, the development of better and more interactive exergames that makes use of the future technology such as augmented, virtual or mixed reality to achieve the purpose of getting gamers to keep moving instead of being sedentary. These fun exergames will henceforth give children motivation to exercise in a fun environment through the use of gamification.

Exergames, such as Pokemon Go had led to substantial activity increase and have the potential to reach activity-poor populations. Research found Pokémon Go leads to significant increases in physical activity with particularly engaged users increasing their activity by 1473 steps a day on average, a more than 25% increase compared with their prior activity level (Althoff et al, 2016). An online survey of Pokemon Go players showed that playing augmented reality games has a positive association with perceived mental, physical and social health outcomes overall (Koivisto et al, 2019). Another study showed that the longer participants had been playing the game, the higher the likelihood that they would engage in exercises (Wei and Wang, 2019). In just 2 months, Pokemon Go players walked 4.6 billion km while playing the game (Forman et al, 2016).

Exergames are effective because they combine exercise with entertainment, creating social and competitive elements to game play. The game creates an amazingly strong motivation for players to seek rewards and uses many successful behavioural changing techniques. The pull of game is so powerful that people forget they are actually exercising while playing (Weller, 2016). Indeed, the best activity is one that one enjoys doing because one is more likely to stick with it (Piercy, 2016). The potential convergence of exergames and mixed reality could motivate physical activity in children (Schwab, 2018). The challenges in this case would be how do we ensure that the distribution of benefits are fair and inclusive.

Our solution makes use of the excessive screen time of children that has been linked to sedentary lifestyles to reverse that trend through exergames. Henceforth, it will help primary school children to maintain a healthy BMI through exergaming, so that they can lead a healthier lives. These exergames will be distributed and sold through online games downloading platforms.

EDB could start working with game companies immediately for exergames on smart phone, to be launched by 2025 and in 2025 for exergames on virtual or mixed reality platform. The exergames on virtual or mixed reality platform will have a full roll out by 2030.

Solution 3: Food Technology

A*Star will encourage the fast and convenient food industry to create healthy versions of the their popular offerings through research and development in Food Technology. The fast and convenient food industry will work with the Research & Development (R&D) sector to

create food that will look, smell and taste the same as their popular offerings but is plant-based, healthier, with less saturated fat, sugar and salt content.

The use of food technology to solve public health problems has a long and impressive history. Three important examples are the pasteurization of milk, the adding of extra nutrients to food and the use of irradiation to kill pests in foods (Meister and Doyle, 2009).

Such research is also in line with the “planetary health diet”, a future trend which according to scientists would save at least 11 million people a year from deaths caused by unhealthy food, while preventing the collapse of the natural world from severe global warming. The diet is largely plant-based and allows an average of 2,500 calories a day (Carrington, 2019). In future, there will be a decrease in meat consumption in order to reduce carbon footprint from animal agriculture, the F&B industry and therefore fast food and convenient food companies will need to adapt and change. This in turn will motivate these industries to participate in such R&D projects as it affects their future survival.

The WIL@NUS Corporate Laboratory has created a healthier satay. It may look, taste and smell like regular satay but it is 100 % plant-protein with reduced saturated fat and they are now looking at creating healthier cooking oils that could reduce cholesterol levels and prevalence of chronic diseases (Ganesan, 2018).

Impossible Foods in Silicon Valley has created a meat-free burger that sizzles in the pan, tastes like meat and ‘bleeds’. Competitors in the industry are creating similar burgers, and there are plans for plant-based steaks and chicken. Other start-ups are pioneering animal-free milk and egg whites (Farrimond, 2019).

Research has shown that foods that are low in energy density (calories per unit weight) can be helpful in weight control by providing fewer calories without making people feel deprived or unsatisfied. Food technology can contribute in the fight against obesity by providing consumers with an increased variety of delicious and enticing food that are lower in energy density (Meister and Doyle, 2009).

Researchers at the National University of Singapore have even invented Taste+ utensils, smart utensils that allow diabetics to drink a beverage without any sugar but it will still taste sweet to them. These smart utensils allow user to taste flavours such as bitter, sweet and sour as well as to select the intensity they prefer, which are absent in the food they are eating, with the help of electrical pulses (Jeyaretnam, 2017).

As the fast food and convenient food industry have persistently attracted children and families despite their negative health impact, food technology can help create healthier versions of these meals. By re-engineering food to have less fat, sugar, salt and fewer calories, while still giving the same satisfaction, even if children consume these, they are more likely to maintain a healthy BMI to lead healthier lives. The reengineered food will be offered by fast food restaurants and convenient food outlets.

Getting a newly-developed food item into the market can take between 6 months and 5 years, depending on regulatory approval, manufacture and research ease (Pereira, 2019). The Government will look into collaborative partnership amongst industry and R&D partners in the next year. Actual R&D from 2020 till 2025, market testing in 2026 and mass roll out by 2027.

Solution 4: SMART glasses with AI Dietitian

MOH will collaborate with Intel/Mitsui Chemicals of Japan or other companies working on smart glasses or AI to create smart glasses which will be sold through schools at subsidised rate to all primary school children aged 6-12. The smart glasses will come with light field display and AI nutrition dietitian.

The AI through ordinary looking smart glasses will scan the food and drinks user consumes to check if it is healthy. The AI will match uploaded photos of F&B in the database and continue to learn when new scans of food are uploaded through the scans. User will also have access to the AI dietitian which will give personalised advise on dietary and physical activity goals. Users can track their meals through a food diary feature which records nutrition information such as calories, fat, carbohydrate and sugar content. With such information and advice from the AI dietitian, children can adjust the portion sizes if they have eaten more or less than a standard serving.

The side panel of the glasses' frame contains a biosensor which can immediately measure the user's real time data such as blood glucose level. The total daily calories consumed and burned, the blood glucose level as well as health advice are given by projecting light field display on user's eyes. Information about obesity and diabetes risk level and whether to cut down sugar intake will also be given. Every smart glasses will automatically adjust focus based on the user's myopia so it ensure that the children have a perfect piece of "prescriptive" glasses.

Both parents and children may not have the necessary information about the nutritional value of food and it is difficult to educate everyone on this. Children are also often unable to make good decisions about their food consumption. With this Light Field-incorporating advisor and sensor, the children using it can make informed decisions based on the advice and information given and therefore have a lower chance of developing obesity. This also gives the user a degree of freedom, a sense of purpose while inculcating food and health knowledge on a day to day basis so that children can make healthy eating and exercise a part of their life, a habit which the device helps inculcate.

Childhood myopia among seven-to nine-year-olds in Singapore is one of the highest in the world (Teo, 2019). Indeed, one in five Singapore children is myopic when they start primary school (Young Parents, 2019) while the prevalence of myopia among Primary 6 pupils is at 65% (Tan, 2018). This means that glasses is a technology that will more likely to be accepted by parents and because the glasses automatically adjust focus based on the user's myopia, it can also replace eye checks that are routinely done in schools. Intel's Vaunt is smart glasses which look just like normal glasses. When users put them on, they see a stream of information on what looks like a screen but it is actually being projected onto their retina. These are smart glasses designed such that users could wear them all day as they weigh under 50 grams (Bohn, 2018). Glasses which allow users to switch focus electronically but only between progressive or multi-focus lenses, was launched in Japan last year by Mitsui Chemicals of Japan (Chan, 2018), taking us a step closer to the glasses we envision.

The JurongHealth Food Log app which is still on research trial uses uploaded photos of food to a database of over 200 common local dishes to allow users to check if their meal is healthy. The app also links to the hospital's Lifestyle Intervention (Liven) programme to set weight-loss goals, exercise targets and hold live chats with the hospital's dietitians and physiotherapists, who monitor the patients' progress. It also has a chat function, which allow for instantaneous feedback from dietitian to user. In future, the team at Ng Teng Fong

Hospital hopes that AI will replace the role of the dietitian's role in communicating with the user. An instantaneous feedback regarding blood sugar levels without the need to pierce the skin and better detection would also help in the prevention of type 2 diabetes at an early stage (Chong, 2019). Indeed, AI and advance biosensors will allow us to have more precise and personalised healthcare in the prevention of childhood obesity and diabetes (Kwan, 2017). Results of the JurongHealth Food Log app trial so far has been encouraging. Almost all of the 20 users on trial experienced weight loss of between 4 to 5% of their initial body weight with around 0.5kg weight loss targeted per week. This could be due to the constant reminders as well as more instantaneous and personalised advice that was given through the app (Chong, 2019).

As such, with an AI dietitian providing health updates and meal information to children, they can make their own decisions and set their own goals, thereby enabling them to maintain a healthy BMI so that they can lead healthier lives without any devices looking out of place on them. The smart glasses will be sold at subsidised rates at the primary schools so it is on par with what parents usually pay for prescriptive glasses.

MOH could collaborate with Intel/Mitsui Chemicals of Japan or other companies working on smart glasses or AI. Together they will work towards the invention of this device from 2023, market testing and refining by 2025 with the first batch manufactured by 2027 and delivered to schools where it will be distributed or sold at subsidised rate, with more pieces manufactured each year.

Solution 5: Interactive Health Monitor and Obesity Simulator

MOH will work with the industry to create the Interactive Health Monitor and Obesity Simulator which will be able to track users' BMI, blood sugar, blood pressure and cholesterol in a non-invasive manner whenever they use it.

The machine will be able to identify users quickly through advanced facial recognition for efficiency. The machine will contain a database about the children's health and the risk of them becoming obese or having type 2 diabetes. It will then give personalised advice to the user on how to prevent contracting these diseases. The product is funded by the government and free of charge for users.

This Interactive Health Monitor can help users find out a lot about their health status and spur them to improve on it. Many children do not have the means or find it inconvenient to find out about these information and parents are not always a good judge of whether their children are obese. This Interactive Health Monitor will not take much time and will be placed in areas that children frequent such as schools and shopping malls. This machine will track users' BMI, blood sugar, blood pressure and cholesterol in a non-invasive manner whenever they use it. Once they have done their BMI and health analysis, children will also be taken on a virtual reality journey on how it really feels to be obese and diabetic as well as the discomfort, inconvenience and stigma the diseases may bring to life by being in the shoes of someone their age who is obese. This obesity simulator will not only motivate them to change their lifestyle and become healthier by following the advice given by the machine but will increase their empathy for people who are obese. A copy of their diagnostics will also be emailed to them and their parents for follow-up.

MOH can also use this machine to collect data. They can combine information from the Interactive Health Monitor and other sources (e.g medical records) to examine how the effects of obesity occurs over a period of time and how it affects the health of the nation's children as a whole. This can also be used to further research on the correlation of eating

habits and exercise to type 2 diabetes and obesity (Levy et al, 2011). The system can also pool information on the health status of the users and thus predict the levels of obesity as a whole within the nation in future when these children become adults (Ward et al, 2017). Using the data collected, AI can provide useful research analysis and recommendations that MOH can use to further counter obesity and type 2 diabetes.

Most parents do not see obesity as a health problem until it is pointed out to them. Some of these parents and children recognise the problem but are not motivated enough to make lifestyle changes. However, the most important thing is for the entire family to recognise the issues and make changes together (Teo, 2014). According to studies, 75% of parents also underestimated the size of an overweight child, while 50% underestimated the size of an obese child (Winterman, 2012). Researchers warned that the lack of awareness of childhood obesity could contribute to the problem, because if parents do not recognise children's obesity, then they would not be able to help them (Alter, 2015).

According to research, prevention of childhood obesity mainly relies on early diagnosis through regular monitoring of BMI and lifestyle modification (Mukhopadhyay et al, 2019). We learnt from our site interview that an instantaneous feedback regarding blood sugar levels without the need to pierce the skin and better detection would help in the prevention of type 2 diabetes at an early stage (Chong, 2019).

Research findings indicate that monitoring through digital intervention could encourage positive lifestyle change given that parents made further lifestyle changes to improve their children's health directly in response to feedback about their children's BMI (Dam et al, 2019). According to our survey, some parents revealed that they are already motivated themselves but they are unsure how to motivate their children. Through the simulator, children will get to experience being obese and diabetic as well as the discomfort and inconvenience they bring to life. This obesity simulator will motivate them to change their lifestyle and become healthier by following the advice given by the machine.

By making such monitors available to children and their parents for periodic checks will enable them to reflect and make lifestyle changes so as to maintain a healthy BMI. This way, they can lead healthier lives without the placement of any device on them.

These machines will be placed in common areas in schools and shopping malls children frequent. MOH and manufacturer can start developing the machine around 2025 and after thorough testing the machine can be placed at schools and malls in the late 2020s.

THE SELECTION CRITERIA

1. Which solution would the community be most willing to adopt such that it would help primary school children maintain a healthy BMI in the most non-invasive manner?

This criteria is most important as health is a personal choice and the users' willingness to adopt the solution is paramount. Parents play a huge role in this aspect. From our survey, we observed that parents are sceptical of future technology and are most unwilling to use invasive and unfamiliar products on their children. This criteria is extremely important as the end product is ultimately used by children aged 6 to 12. If their parents are unwilling to allow the use of such product, the desired outcome will not be achieved.

2. Which solution would be most effective in the long run for primary school children so that they could build healthy lifestyle habits which would help them maintain a healthy BMI?

This criteria is extremely important because maintaining a healthy BMI in the long run requires lifestyle changes and building of good habits. The development of healthy habits begin from young, and sustained through to adulthood (SingHealth, 2018). We want a solution that will work for the majority of the target group and even be relevant for new students entering primary schools. The product should also be easy to repair as well as update.

3. Which solution would involve the most key influencers in the children's life so that primary school children would be motivated to develop healthier habits to maintain a healthy BMI?

This criteria is very important as parents, peers and the school can all play important roles in helping children maintain a healthy BMI. The involvement of these key influencers in the children's life could motivate behaviour and lifestyle changes the solution facilitates, thereby building habits to maintain a healthy BMI.

4. Which solution would be the easiest for the community to integrate seamlessly into their lifestyle so that it can help primary school children maintain a healthy BMI?

This criteria is very important as the end product should be convenient and easy to use so that the end users can integrate the solution into their daily lifestyle more seamlessly, allowing them to be more comfortable with it and becoming part of their lifestyle. However, it is not as important as the above as parents will be willing to use the product even if it is not the easiest to integrate into their lifestyle, if the effectiveness in ensuring their children stay healthy outweighs the additional effort.

5. Which solution would be the most affordable so that most members of the community have access to it to help primary school children maintain a healthy BMI?

This criteria is important as the cost of product must be affordable to allow for greater accessibility for end users. If the product cost is too high, those potential end users from weaker financial backgrounds may not want or are unable to fork out the sum of money. However, this criteria is less imperative than those above as the government can give subsidies or sought corporate sponsorship for the product or the product may even be given free.

CRITERIA ANALYSIS	Criteria 1: Most willing to adopt by parents	Criteria 2: Most effective in the long run/ build habit	Criteria 3: Most key influencers to motivate	Criteria 4: Easiest to integrate into users' life	Criteria 5: Most affordable for users	Total
Solution 1: <i>WRIST Fit</i>	4 Non-invasive, human-AI collaboration	5 Affects diet and physical activity with reminders, limits	5 Family, school and peer	2 Rather intuitive	4 Free	20
Solution 2: Food Technology	5 Non-invasive, plant based sound healthy. Food is essential	1 Kids can still be obese if they overeat/do not watch their diet	1 Nil	5 No effort, status quo	3 Food price	15
Solution 3: Exergames	2 Non-invasive, parents may be concern about further addiction as this could replace or increase current screen time	2 Even though physical activity increases, people can still be obese if they overeat/do not watch their diet	4 Peer	4 No effort, already playing games just new physical movement aspect	2 Price of App or in-game purchases	14
Solution 4: AutoCorrect Smart glasses with AI Dietitian	3 Non-invasive, Parents comfortable with glasses but apprehensive of AI	4 Affects diet and physical activity with reminders	2 Nil, only AI	3 Rather intuitive	1 Price of prescriptive glasses	13
Solution 5: Interactive Health Monitor and Obesity Simulator	1 Non-invasive, Out of sight out of mind and not 24/7. May forget after a while.	3 Affects diet and physical activity But to lesser degree	3 Family but less control	1	5 Free	13

ACTION PLAN: *WRIST Fit*

IMPLEMENTERS AND ASSISTERS

MOH will work with Xiaomi or any other companies working on wrist wearable for chronic disease prevention, to create a health wrist wearable for primary school children (6-12) in Singapore. Called *WRIST Fit*, MOH will implement this health wrist wearable programme in collaboration with MOE primary schools and parents. Transit-link will be supportive as it allows a more convenient and safe method for primary students to pay for discounted public transport fares and parents for topping up the amount as they too look into future technology for transit payment. Already in Shenzhen, China, facial recognition ticketing is being tested for subway rides (Li, 2019). MOH will work also with Ministry of Law (MinLaw) to look into regulations pertaining to protection of individual information rights to ensure the children's privacy are protected on top of data security protection.

DISTRIBUTION

WRIST Fit will be distributed to all MOE primary school students through the schools but can be used anywhere.

THE *WRIST Fit* PROGRAMME

WRIST Fit not only acts as a payment, transit-link and identity device but can track students' exercise level, dietary intake and health status such as blood sugar and obesity threat level. It is capable of showing data through the interactive screenless interface, the equivalent of mobile devices in the future. To encourage physical activity, we introduce the element of a leader board, bonus points, rewards, level, badges and guilds. Friends can form guilds where the children work together and encourage one another to win other guilds through the combined level of physical activity. Children can access their rewards catalogue on their interactive screenless interface where they can potentially earn vouchers, avatar upgrades, apps, gift cards, VR game goggles or even donate to charities of their choice. Children can customise *WRIST Fit* through colour or photograph selection (where part of the photograph becomes the strap design) and can also create upgradable avatars of themselves. The interactive screenless interface mode will also allow adding friends, joining guilds and the setting of daily physical activity objectives.

Parents will receive notifications when the child has not been exercising regularly or has been consuming too much unhealthy food. Parents can then choose to set a limit to the consumption of certain food groups such as fast food, convenient food, sugar sweetened beverages or simply a daily sugar limit based on AI's recommendation. The availability of such food will no longer appear on the specific child's interactive screenless interface and the payment for such food groups will not be approved once the limit has been reached. From our survey, 62.7% of parents surveyed would like to set a limit to their child's daily sugar intake by making the decision on their own based on the AI's recommendation. To combat the effects of sedentary gameplay, parents can also set a limit such that children have to achieve a minimum step count or activity rate before they could play sedentary games.

Using AI, the IoT and real time monitoring, recommendations will be sent to parents and students on how to improve on the user's diet and exercise routines. Children will be advised to set goals based on AI recommendations and approved by parents. *WRIST Fit* also sends timely reminders to children to take their three main meals and three nourishing snacks a day as these help reduce cravings for sweets and unhealthy food (Wee, 2016). Indeed, children who skip main meals are more likely to eat more unhealthy snacks and may end

up overeating (Department of Child Development, KK Women's and Children's Hospital, 2018).

With the rise of 4IR, *WRIST Fit* will be connected through 5G, allowing real time health and dietary data to be measured and analysed by AI to help with real time decision making by students and parents. Schools will also have access to selected information so as to give awards to motivate primary school children to exercise more and eat healthier food. Interschool competition can also be organised to encourage friendly competition and to increase physical activity. Henceforth, with this programme in place, it will help primary school children maintain healthy BMI through the means of parental monitoring, peer motivation, gamification and friendly competition.

Quantum Cryptography which will become more accessible and affordable in future will be used to ensure security and prevent data breaches. Activated by face recognition, the device will only work on the specific student and not others, it will be weatherproof and can only be removed by parent or guardian.

IMPLEMENTATION TIMELINE

MOH, MOE, Transit Link and Xiaomi will start discussions immediately to work out the cost and budget of the project. MOH will secure a long term corporate sponsor and work with MinLaw on regulations to support the initiative by 2020. Xiaomi will make enhancement to its device to incorporate the government agencies' needs by 2024. Together, the collaborators can look into testing in 2025 in pilot school and nearby MRT stations, improvements by 2026 for re-testing and full roll out by 2027. Subsequently, every batch of primary one students will be assigned these wrist wearables. Upgrades will be downloadable free from the interactive screenless interface.

OBSTACLES AND RESISTORS: MANAGING AND OVERCOMING THEM

Addressing Affordability and Accessibility

Many parents surveyed are concerned about affordability and some also commented that a free product will motivate them to use it for their children. As such, the cost of the product could potentially pose a problem to user's willingness to adopt the technology.

While it can be argued that given the lifetime medical costs for one obese child is S\$24,000 more than a normal weight child (Teo, 2014) and in addition to these immediate costs, childhood obesity implies future direct costs given that obese children are more likely to become obese adults. In addition, given that the cost burden of diabetes is set to rise from \$940 million in 2014 to \$1.8 billion in 2050 in Singapore (HealthHub, n.d.), the cost of manufacturing a device for the prevention of childhood obesity and diabetes is negligible, the government may still meet resistance from tax payers if the government uses its health budget to fund this.

As such, to increase its accessibility, we recommend that MOH look for corporate sponsors to off-set the cost of *WRIST Fit* and its rewards scheme for children (non-food related). Corporate sponsors have been coming forward to support health initiatives in Singapore. For instance, on 18 June 2019, SingHealth received a \$40 million donation from Ngee Ann Development for medical research and efforts to advance patient care (Liu, 2019). Both Khoo Teck Puat Hospital and Ng Teng Fong Hospital received \$125 million each in donation to fund healthcare for needy patients and other programmes (Ong, 2014).

As such, the objective is for *WRIST Fit* to be distributed **free** to all primary school children thereby making it accessible to all, reducing potential inequality based on socio-economic status, which is another challenge of 4IR.

Addressing Technical Stability

It is important to get the technology right so that users can immediately experience the seamless ease of use. Our site visit has taught us that this is vital. While the JurongHealth Food Log app trial has helped patients to lose weight, some problems exist such as hanging, slow in resetting password, good with only local foods that it recognises, can be very tedious to add more dishes to the database as at least 200 photos are required for 1 dish and can be difficult to stabilise because of the sheer amount of information (Lee, 2019). We want to ensure that the solution is thoroughly tested so that these issues will not exist during implementation which is why pilot testing and enhancement have been factored into the timeline. Free routine downloadable updates will also help ease the issue of technical instability.

Addressing Some Parents' Unwillingness to Adopt New Technology

According to our survey, while 62.6% of parents would like to set a limit to their child's daily sugar intake by making the decision on their own based on AI's recommendation and 22.7% want to decide on the limit entirely on their own. However, 5.5% of parents do not wish to set a limit at all while 17.2% of parents indicated that they did not wish to track their child's daily dietary intake nor physical activity. While the latter represents the minority, it is an indication that resistant might come in the form of parents being unwilling to use the health benefits of *WRIST Fit* for their children as they wish for their children to not depend on technology or to have a greater degree of freedom.

In order to overcome this resistance, MOH and MOE can convince parents that this is a measure to help their children reduce their risk of childhood obesity and type 2 diabetes and it is for the greater benefit of our next generation and our society, and that its ultimate purpose is the well-being of the child. In addition, parents will also be informed of the medical and cash benefits which will be given to them if the child manages to maintain a healthy BMI. From the open ended questions in our survey, some parents indicated these as incentives that will motivate them to use the system to monitor their kids.

It can also be highlighted that if the child is able to maintain a healthy BMI without any parental intervention, child and parent will also be told "good job" or given words of encouragement by the system. It is only if the child consistently overeats, overindulges in high sugar diet or falls below the minimal physical activity of at least an hour of being active each day that the AI will prompt parents with recommendation on setting limits for the child. When the AI's analysis indicates that the child has consistently maintained a healthy lifestyle and is capable of maintaining a healthy BMI on his or her own, AI may make recommendations for parents to remove the limits. The emphasis will be on weight maintenance for normal weight children or a slower weight gain to allow a gradual reduction in BMI for obese children who are still growing (Health Promotion Board, 2016).

MOH and MOE can also convince parents that *WRIST Fit* will make it more convenient for parents to complete certain tasks, including automatic top-up for transit-link or setting daily or weekly allowance for their children linked to their bank account.

Addressing Security and Privacy Concerns

Some parents may also view *WRIST Fit* as a threat towards their child's privacy and security, if hackers somehow manage to break into the system. MOH can work with the MinLaw to

look into regulations pertaining to protection of individual information rights to ensure the children's data are legally protected. With quantum cryptography becoming not just more accessible but more advanced in the future, the collaborators can work towards using quantum cryptography, the most advanced and theoretically un-hackable security system invented so that parents will no longer view safety and security as concerns. *WRIST Fit* is removable only by parents and is Wi-Fi chargeable so no dock charging is required.

From our survey, parents stated that convenience, ease of use, privacy and security ensured, a nationwide holistic approach of school and family in managing child's health, government incentives and cash rewards, free tools, accurate, non-invasive with minimal radiation, child will not be able to remove device on his/her own as factors that will motivate them to use future technology to help reduce their child's risk of obesity. Due to the value-add, convenience and security behind *WRIST Fit*, as well as having more benefits that outweighs cost, some resistance from the parents will be overcome.

Nonetheless, we realise that a small minority of parents may still not use *WRIST Fit*. However, we believe that even if we can prevent childhood obesity by 30%, it will make a substantial impact as children can influence other children through peer motivation, these children are more likely to grow up as healthy adults with reduced risk of obesity and hence less likely to suffer from chronic illnesses, thereby resulting in less burden on family, society, economy and public healthcare.

Addressing Primary School Students' Willingness to Use *WRIST Fit*

For *WRIST Fit* to work, it will be an issue if primary school student do not wear the device as planned.

To ensure that all primary school students wear the device, we made it an indispensable wearable. With 4IR and face recognition payment being a norm in the future where facial recognition allows consumers to make payment via a direct deduction from their bank account (Mokhtar, 2019). *WRIST Fit* not just facilitates the payment for food in the school canteen but all sorts of payment for children such as library fines, stationery delivery and even payment that takes place outside of school such as in a grocery store. It is also an additional form of payment security with two factor authentication. In addition, it is a transit-link device for enjoying student rates while taking public transport and the student's identity device for taking daily attendance in school, thereby making it indispensable for the user.

There may also be resistance from children as they may feel that *WRIST Fit* would be limiting their freedom. However, we will point out to them that *WRIST Fit* does not allow parents to gain complete control over their lives and that the AI recommendations are not to completely deprive children of certain food or entertainment but to steer them towards a more balanced lifestyle. After all, healthy eating habits should be developed gradually as an overly restrictive diet is likely to fail (Department of Child Development, KK Women's and Children's Hospital, 2018). According to experts, when children ask for junk food, it is better to give them a little than to deny them altogether, as this would cause the children to desire them more (Wee, 2016). It is better to allow small amounts of foods like chocolate, ice cream or tit-bits once weekly than not at all (Department of Child Development, KK Women's and Children's Hospital, 2018). The AI will thus take this into consideration, allowing not just for a humane solution but positive result in the long run. If children are not obese yet, the objective is not to make them lose weight but to maintain a healthy BMI. Even if the child is overweight, he or she is also growing. Therefore, the objective is not for him or her to lose weight but rather to gain weight at a slower rate (Department of Child Development, KK Women's and Children's Hospital, 2018). As such, *WRIST Fit* will empower children to learn

to make decisions and develop healthier habits while motivating them to maintain a healthy BMI without depriving them.

Having fun while moving with peers is what we want the children to enjoy and so long as healthy eating and physical activity aspects are fulfilled, parents are not likely to set limits as AI will make reasonable recommendations to them. There is also the added fun aspect which allow customisation by children, fun competition with peers as well as rewards to motivate them. Interschool competition and school awards will further motivate children to be physically active. 74% of parents surveyed believed that gamification would very much motivate their children to engage in physical activity while 78% felt that school giving awards to students based on physical activity will very much or somewhat motivate their children to lead a healthier lifestyle.

Addressing Concerns of the F&B Industry

The fast and convenient food industry as well as the sugar sweetened beverages industry may resist this solution due to the fact that it may negatively affect business as parents may choose to limit their child's ability to purchase unhealthy fare. We can tackle this resistance by informing them that *WRIST Fit* only limits the children buying fast and convenient food themselves when they have exceeded the recommended limit. It does not mean they cannot buy any fast or convenient food at all. As per government regulations against advertisements by F&B targeted at children on traditional media, we believe the industry will have to align itself to this initiative. We hope that as a consequence, this may prompt the industry to rethink and come up with healthier selections for primary school children so that such limits can become obsolete.

CONSEQUENCE AND EFFECT OF ACTION PLAN

More Children Maintain Healthy BMI and Develop into Healthy Adults

With 4IR, robots, VR and AI will enhance the marketing and delivery of fast food and video games to children thereby increasing their consumption while reducing physical activity leading to an increase in childhood obesity and type 2 diabetes. To make matters worse, "the evolution of technology has reached a point where pretty much anything is available at the touch of a button..... those who will suffer most will be children" (Zollinger-Read, 2013). Even if schools were to ban sugary-sweetened beverages or fast food in canteens, students with the means will be able to make use of drone delivery technology in the future and order such food products for consumption.

As such, parents need *WRIST Fit* to guide children when they themselves happen to be absent. AI's recommendations will be helpful in guiding parents and children in making health related decisions more wisely. The limits recommended by the AI will not be completely excessive, as the AI is meant to help solve the problem of over consumption of unhealthy food and overeating, not to deprive the children completely. Children can also give feedback to and have discussions with parents, creating more opportunities for parents to inculcate food knowledge to their children based on information gathered from AI.

Our aim is to maintain a healthy weight appropriate for the height of the child. The best way to achieve this is by making small but permanent changes in eating habits and physical activity, instead of drastic changes that do not last for long (Department of Child Development, KK Women's and Children's Hospital, 2018). For children, even a small 200 to 300 kilojoules, the equivalent to just two sweet biscuits, excess in food intake can lead to unhealthy weight gain. This would require 20 minutes of walking to equalise. We believe that when empowered with information that *WRIST Fit* provides, small changes have the

potential to make a big difference (Mitchell & Baur, 2019). Healthy habits inculcated from a young age also tend to persist into adulthood, which would go a long way towards preventing chronic illnesses (Yang, 2019).

Research on mHealth (mobile and wearables) found that it is more effective than conventional approaches in behaviour modifications and lifestyle changes to prevent and control obesity (Bhardwaj et al, 2017). As such, *WRIST Fit* can help primary school children maintain a healthy BMI so that they can lead healthier lives in Singapore from 2027 and beyond by motivating children to be physically active through parental monitoring, peer motivation, gamification, rewards and empowering them to develop healthy eating habits by making small significant changes. Consequently, more children will be able to grow up as healthy adults.

According to Michael F. Neidorff, Chairman and Chief Executive Officer, Centene Corporation, with preventive measures using technology, a huge number of people can have more normal lives because of intervention before the onset (World Economic Forum, 2018).

Parents Make Lifestyle Changes

In the prevention of childhood obesity, parents need to be involved as they are important influencers in their children's behaviours and play a significant role in supporting healthy practices in and outside of the home (Lindsay et al, 2006). Research has shown that both the threat of and actual parental monitoring lowered the number of non-nutritious foods chosen and total caloric content of the meal chosen by kids (Klesges et al, 1991).

In a research, only 14% of the parents correctly identified obesity in their child (Gwozdz et al, 2015). *WRIST Fit* prompts parents when the risk of obesity is identified in a child so that a parent can make better decisions earlier to help his or her child through setting limits or a change of lifestyle. Research findings support this as monitoring through digital intervention could encourage positive lifestyle change and support healthier child growth given that parents reported making further lifestyle changes within their family to improve their children's health directly in response to feedback about their children's BMI (Dam et al, 2019).

Interviews with obese children and their families reveal that regular family activities often include food or eating but rarely physical activities. Hence, it is hardly surprising that obese children often have obese siblings, parents or grandparents as members of the family have a similar diet and lifestyle (Sports Medicine Service, 2018). As such, by alerting parents of a child's risk of obesity due to dietary and lifestyle habits could help parents recognise the risk and to make changes for the good of the family and children.

Move from Sedentary Games to Physical Activity and Exergames

There is also the issue of a sedentary lifestyle significantly caused by digital devices, games and entertainment. A 2014 study showed that teenagers who spent more time watching TV, playing video games or on a computer were more likely as young adults to be obese (American Heart Association, 2018). To make things worse, increasingly AI are used in content platforms to make gameplay more addictive (Douetteau, n.d.). With 4IR, the virtual and augmented reality of the future will make game play and entertainment even more attractive to children, as such incidental exercise rates will be greatly reduced, bringing up childhood obesity rate. As AI and robots do things more for us, children will have more free time and yet, it is likely that the time will be replaced with even more sedentary game play if nothing is done about it.

Research suggests that children are more likely to increase their levels of physical activity throughout the day due to wearable activity trackers. Moreover, evidence suggests that behavioural changing techniques used by fitness trackers may reduce the prevalence of childhood obesity (Sabina, 2018). Research also suggests that wrist wearables will produce the desired results of increased physical activity in children when they are worn correctly, are adequately engaging, and when they are designed in a manner that is appealing to children. For instance, devices that children are able to customize, wear comfortably, used for any occasion, and are fun/engaging to use (Sabina, 2018).

From our survey, 52% of parents chose wrist wearables as the technology they are most willing to use for this purpose. Features such as self-monitoring, goal setting, feedback on activity, rewards and encouraging competition and challenges among social circles all aid in weight control (Forman et al, 2016). Studies also suggest that the presence of healthy eating peers can influence healthier food selection and that positive friendship experiences foster engagement in physical activity (Salvy and Bowker, 2014)

WRIST Fit combats a sedentary lifestyle by encouraging physical activity through gamification, friendly competition and peer motivation, it also steers children towards game play which involves exercise/ movements such as exergames, moving them away from sedentary ones.

Reduce Burden on Family, Society and Public Healthcare

We will be inculcating healthy eating and exercise habits in future generations of Singaporean. Childhood obesity can develop into many different health problems when obese children become obese adults, such as cardiovascular disease, insulin resistance, musculoskeletal disorders and some cancers (World Health Organisation, 2014). The National Health Survey 2010 shows that 1.7 million Singaporeans with a BMI of 23 or more are vulnerable to developing obesity-related diseases and that 1 million of them are either pre-diabetic or suffering at least one chronic illness. Research has shown that obesity-related diseases had the largest impact on health in terms of suffering and cost (Health Promotion Board, 2014).

These diseases are also burden on families, society and public healthcare. According to Albert Bourla, Chief Operating Officer of Pfizer, “Sickness is a cost on society...A lot of these illnesses are preventable and managed much better with technology” (World Economic Forum, 2018). We believe that *WRIST Fit's* effectiveness in helping children maintain a healthy BMI will reduce its burden on family finances as well as time and effort in caring for the sick. Singapore hospitals are already facing a bed crunch issue, when demand overwhelms, patients are allocated beds along corridors (The Straits Times, 2017). The prevention of childhood obesity and diabetes will not only lead to a healthier population and workforce, reducing the burden on public healthcare budget expenditure and its magnitude of related medical costs significantly but also reducing the burden on hospitals and healthcare staff with more pertinent issues to deal with given our nation's aging population.

Reduce Risk of Diabetes, Heart Disease and Cancer

A study found that having a high BMI is the largest single contributor (73%) to Singapore's burden of diabetes (Health Promotion Board, 2014). As such, the prevention of childhood obesity could lead to a significant reduction of diabetes in our population, already the second highest amongst developed nations.

Research has shown that obesity leads to shorter lifespan and people with obesity suffer cardiovascular disease over longer periods of their life (Northwestern University, 2018). As

such, the prevention of childhood obesity could lead to a longer lifespan for our population and reduce suffering.

According to experts from John Hopkins, obesity will overtake smoking as the number one preventable cause of cancer in five years' time as the chronic illness leads to increased risk to 13 types of cancers (McGinley, 2019). Hence, by preventing childhood obesity, we will also be preventing cancer and reducing suffering in our future generation.

Increase Productivity and Economic Competitiveness

Obesity has an impact on the economy and productivity at work. Having a healthier population will result in less absenteeism from work. In addition, research has found that obesity is linked to more hours of lost concentration, repeating a job, or feeling fatigued at work, thereby reducing individual productivity (Hammond & Levine, 2010).

As such, an effect of *WRIST Fit* will also be enhanced productivity of the future workforce and economic competitiveness for the nation.

Conclusion

WRIST Fit is our attempt at minimising the probable risk and harm that 4IR may escalate in the health of our future generation and uses AI-human collaboration to improve lives and help to counter potential damages brought about by an increasingly 'obesogenic environment'.

An article in TODAY on 28 July 2019 highlighted recommendations from HealthySG taskforce chaired by Mr Amrin Amin, Senior Parliamentary Secretary of Home Affairs and Health for a healthier Singapore and one of the proposals was health promotion through wearables (Ng, 2019). This is from a panel of experts and in line with the initiative which we feel should start from young.

In conclusion, we are confident that *WRIST Fit* can help many of our primary school children maintain a healthy BMI from 2027 and beyond so that they can live healthier lives.

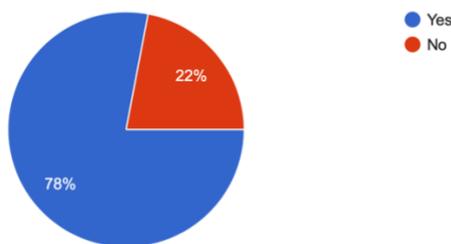
ANNEX A: SURVEY RESULTS AND ANALYSIS

A pilot survey in the format of a Google Form was conducted to test the appropriateness of questions to the target population. It also tested the correctness of the instructions to be measured by whether all the respondents in the pilot sample are able to follow the directions as indicated. We received 59 responses for the pilot survey of which 43 responses were from parents with children aged 6 to 12.

A full scale survey in the format of a Google Form was disseminated to parents via Whatsapp, social media and through the help of primary school teachers. Additional surveys were collected at enrichment centers. Our research objective was to identify potential challenges to find out parent's needs and concerns so as to conceptualise better solutions for the prevention of Childhood Obesity and Type 2 Diabetes in primary school children (6-12).

1. Do you have primary school children (6-12 year olds)?

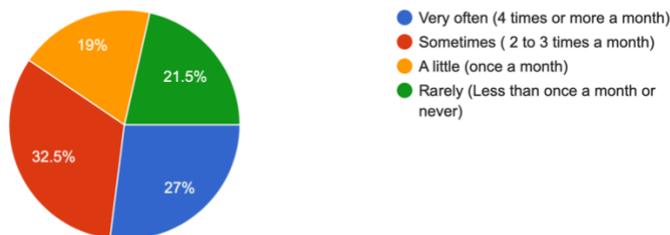
209 responses



There were 209 respondents to the survey of which 78% or 163 respondents are parents with primary school children (6-12). Only responses from the latter group are included in our analysis so that it is representative of our target population.

2. How often do you educate your child on diabetes and/or obesity?

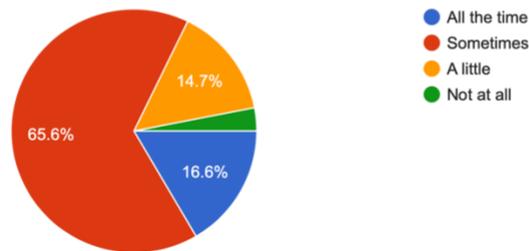
163 responses



27% of parents educate his or her child on diabetes and/or obesity 4 times or more a month, 32.5% of parents educate his or her child on diabetes and/or obesity 2 to 3 times a month, 19% of parents educate his or her child on diabetes and/or obesity once a month and 21.5% of parents educate his or her child on diabetes and/or obesity less than once a month or have never done so. This meant that, majority or 78.5% of parents tried to teach his or her child about diabetes and/or obesity once a month or more. This showed that majority of parents are concerned about childhood diabetes and/or obesity.

3. Do you think your child follows your advice on what they should or should not consume?

163 responses

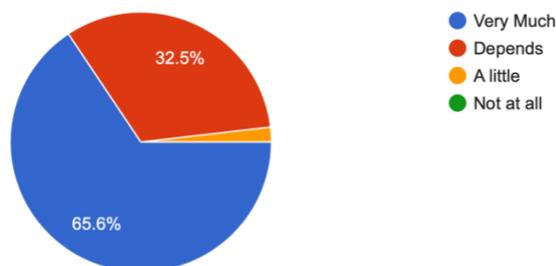


65.6% of parents surveyed believe his or her child follow their advice on what they should or should not consume sometimes while 14.7% believe his or her child listen a little to their advice and 3.1% of parents believed his or her child do not listen to their advice at all. As such, 83.4% of parents believe his or her child did not listen their advice all the time and only 16.6% of parents believe his or her child listen to their advice all the time. This is in line with research that showed parents of primary school children do not know what their kids consume in school or have no control over what they consume (Gonzales, 2016).

As such, majority (83.4%) of children do not listen to their parents all the time, even though majority (78.5%) of the parents tried to educate them on obesity and/ or diabetes once a month or more.

4. How much do you as a parent care about the food and drinks your child consumes on a daily basis?

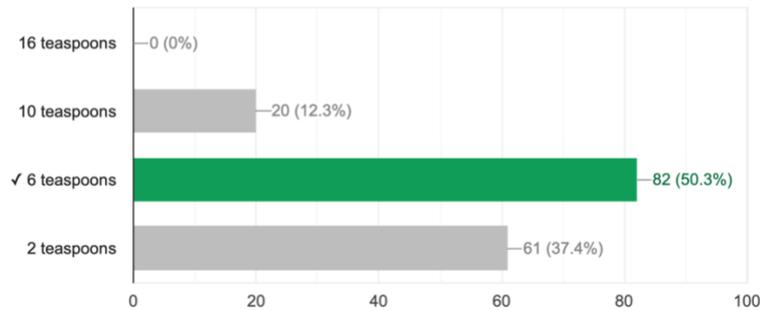
163 responses



65.6% of parents care very much about the food and drinks their child consume on a daily basis.

5. What do you think is the maximum amount of sugar your child can consume a day in order to remain healthy?

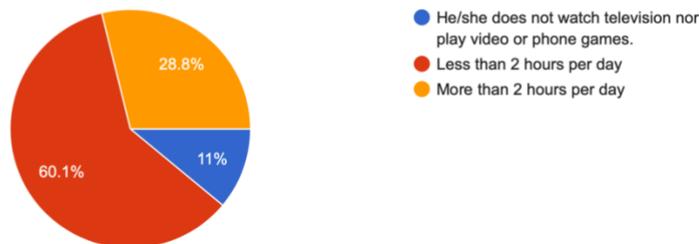
82 / 163 correct responses



Only 50.3% of parents got the correct answer for this question, an indication that around half of the parents themselves do not have accurate knowledge on daily dietary and health needs of their children. As such, parents on their own, might not be able to make the best dietary and health decision for their child.

6. How long does your child spend on watching television, playing video or phone games per day?

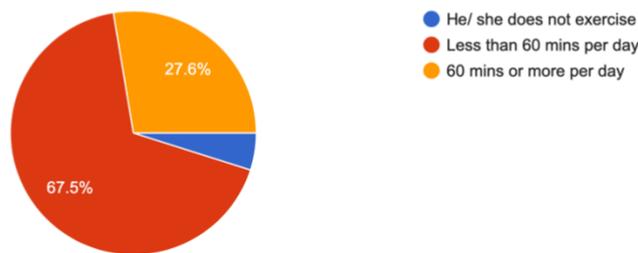
163 responses



The recommended screen time for primary school children is not more than 2 hours per day. In a 2017 study, 12 year-olds in Singapore spend over 6½ hours daily glued to a screen. (Yang, 2017). This over indulgence in screen time results in a largely sedentary lifestyle, which is the main cause of obesity. (ActiveHealth, 2019). In our survey, 60.1% of parents surveyed indicated that his or her child spend less than 2 hours per day watching television, playing video or phone games. 28.8% of parents indicated that his or her child spend more than 2 hours a day on these activities. Only 11% of the children do not engage in these screen related activities at all.

7. How long does your child exercise (anything that increases heart rate and makes them get out of breath some of the time) per day?

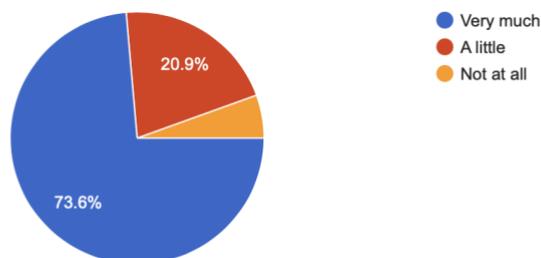
163 responses



The recommended physical activity for primary school children is at least an hour a day. The 1.5 hours per week of PE in school is way below this requirement. The National Sports Participation Survey (2011) revealed that 55% of parents with children below 12 indicated that their children did not do any sport outside school (See, 2015). In line with this data, our survey research showed that 67.5% of parents with primary school children (6-12) indicated that their children did less than 60 mins of exercise per day. To make matters worse, 4.9% of primary school children do not exercise at all. This meant that in total, 72.4% of these children exercised less than an hour a day.

8. Do you think that your child would be more motivated to exercise if there is gamification (Adding fun elements, entertainment, creating social and competitive elements to game play) in the process of tracking your child's exercise level?

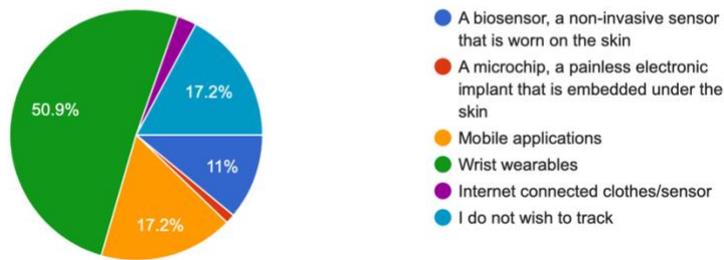
163 responses



Majority or 73.6% of parents surveyed believed that gamification would very much motivate their child's level of physical activity. This is in line with research that has showed that ExerGames, such as Pokemon Go had led to substantial activity increases and have the potential to reach activity-poor populations. Microsoft is working on Mixed Reality where our field of view becomes a computing surface as our digital and physical world becomes one. The potential convergence of ExerGames and Mixed Reality could motivate physical activity in children. The challenges in this case would be how do we ensure that the distribution of benefits to be fair and inclusive.

9. Which of the following technology will you be most willing to use for tracking your child's daily sugar/calorie intake/physical activity ?

163 responses



Research on mHealth found that it is more effective than conventional approaches in behaviour modifications to promote weight loss and lifestyle changes to prevent and control obesity (Bhardwaj et al, 2017). While more advanced technology will be available as a tracking device for their child's dietary intake/ physical activity, our research showed that parents prefer the least invasive devices and also those they are familiar with. 50.9% of parents chose wrist wearables as the technology they are most willing to use. 17.2% chose mobile applications while 11% chose a non-invasive bio-sensor. Only about 2% chose microchip implant which is considered more advanced but more invasive. Only about 2% chose Internet connected clothes which though are non-invasive but is a new technology parents are not familiar with. 17.2% of parents indicated that they did not wish to track their child's daily dietary intake/physical activity. This is in line with one of the challenges of 4IR which is the stakeholder's willingness to adopt the technology. Getting humans to get their own microchip implants has so far been a tough sell. (CBN News, 2018). In order for a better end-product, it is important for us to consider community's views in order to ensure that a majority of the community will be willing to make use of our end-product. (Glinos, 2018)

8. Would you like to set a limit on your child's daily sugar limit manually? Or would you rather allow Artificial Intelligence to decide?

43 responses

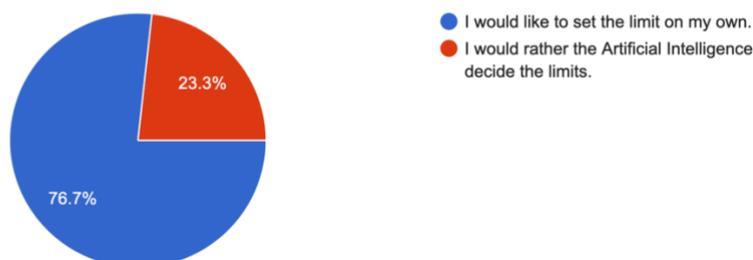


Figure 1 Original question from pilot survey

A 2018 research by Marmett observed that AI systems has the capacity to provide accurate results when analysing data from various sources and could be well applied to the management of obesity. However, during our pilot survey, we realised that 76.7% of parents are sceptical of AI and do not wish to have AI make decisions for them (see Figure 1).

According to Schwab (2018), AI's most urgent application is in healthcare and AI-human collaboration is an important area of consideration. As such, the survey question was amended to provide more options such as human-AI collaboration for parents' consideration (see Figure 2).

10. How would you like to set a limit on your child's daily sugar limit?
 Artificial Intelligence would make a decision based on a detailed analysis of the electronic health record of the child, the blood sugar level of the child, the BMI of the child as well as how much sugar your child should consume a day.

163 responses

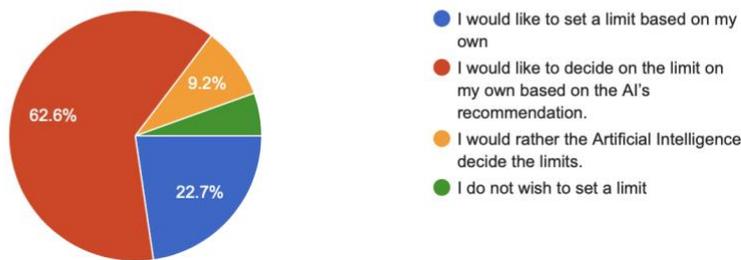


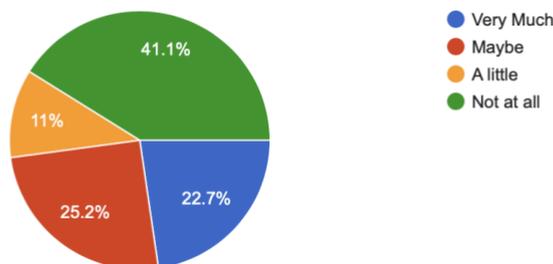
Figure 2 Revised question offering more options in actual survey

62.6% of parents surveyed would like to set a limit to their child's daily sugar intake by making the decision on their own based on the AI's recommendation. 22.7% would like to set a limit on their own. Only 9.2% would like the AI to decide on the limits and 5.5% do not wish to set a limit at all.

Indeed, we need to have a mindset of empowering, not determining when implementing 4IR. We need to value human decision-making so as to design technologies that gives people more choices, opportunities, freedom and control over their lives. This is especially important given the ways in which technologies like AI that can make decision and act without human input and influence us (Schwab, 2018).

11. Do you think you will be more motivated to encourage healthy eating and physical activity in your child if his/her risk of obesity is linked to the taxes paid by your family? e.g. Family with an obese child can pay lower tax when there is a percentage reduction in the child's BMI compared with the previous year.

163 responses



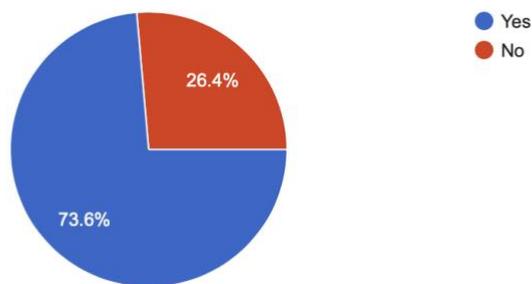
41.1% of parents do not think tax incentive would motivate them more to encourage healthy eating and physical activity in their children at all. 22.7% of parents would very much be

motivated by tax incentives, 25.2% of parents might be motivated by tax incentive and 10% will be a little motivated by tax incentive.

From our open ended question (see below), parents stated that convenience, ease of use/ hassle free, privacy/ security ensured, a nationwide holistic approach of school and family in managing child's health, government incentives/ cash rewards/ rewards points for redemption, free tools, accurate, non-invasive/ minimal radiation/ safe, child will not be able to remove device on his/ her own, evidence based approach/ proven to be helpful are factors that will motivate them to use future technology to help reduce their child's risk of obesity.

12. Will you be willing to work with your child's school canteen vendors using communication technology and recommendations by AI to come up with healthy menu options for your child?

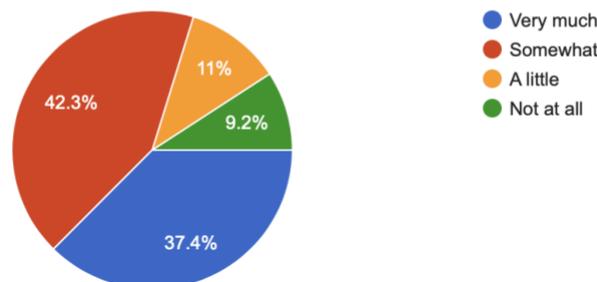
163 responses



Majority or 73.6% of parents are willing to work with school canteen vendors using communication technology to create healthy menu options for their children.

13. Do you think that your child would lead a healthier lifestyle if the school gave awards to students based on their level of physical activity and/or sugar intake?

163 responses



37.4% of parents felt that school giving awards to students based on physical activity/ sugar intake will very much motivate their children to lead a healthier lifestyle. 42.3% of parents felt that school giving awards to students based on physical activity/ sugar intake will somewhat motivate their children to lead a healthier lifestyle. 11% felt this will have little effect while 9.2% felt it will not be effective at all. As such, majority or 79.7% of parents felt that school giving awards will motivate primary school children to lead a healthier lifestyle.

Survey Open Ended Questions

14. How do you think future technology can best help you reduce your child's risk of obesity?

Social media and peer influence

It helps my child be aware and possibly also more responsible for his own sugar intake and hence, risk of obesity.

Using tech to educate and guide along daily will be useful

Technology limits from school canteens

accurate tracking and timely warnings

Tracking and real time feedback on progress.

For tracking and reminding purpose

By tracking, monitoring and rewarding kids whenever their sugar intake level and physical exercise level are within the healthy/recommended range.

Introduce more workout related apps

Through games

To interest them to be active and reduce intake of sugar. Games that involved mobility than stationery. Rewards in terms of points or vouchers for attaining set goals of sugar intake reduction.

Prompting kids to compete the duration spent on exercise outside of school.

I think it would be good if we could have an app or an easy mobile machine that can track the amount of sugar that the child has taken for that day.

It may remind my child from time to time

Every foods comes with the calories count

Educate them and with the help of school teacher.

Assist the parent in monitoring the food & drink consume by the child when parent is not around with them.

Future technology that requires physical movements; or gaming with human contacts e.g. lasertag

Augmented reality games like pokemom go and x box

Increasing awareness of sugar intake will help child make an informed decision

Track and analysis food intake

Provide a platform for them to track and monitor their BMI

Reminder and analysis will be helpful

Provide dietary advise and health check

Same taste, different ingredients

GMOs

Through AI

Ease in tracking progress

Games which will require them to be more Mobile, and apps that can track their physical activity & sugar/carb intake

As a feedback provider with advice on possible solutions

Providing regular updates on sugar intake, AI recommended level of sugar intake, level of exercise and pre-diabetic symptoms warning so that pre-emptive actions can be taken.

Easier access to information and monitoring of obesity level.

An app of sorts that allows you to screen-capture the food item in front of you to reveal the amount of sugar (and % breakdown of nutrients) in that item

It can't most likely, cos they won't listen.

Provide information to monitor sugar intake and activity level of my child.

Alert parents on unhealthy actions of child

A comprehensive app that can track homework study plan and reminder to stop playing mobile phone or computer games (lock after certain time).

More healthier food available

Convenience, accuracy

Creating awareness of the condition / constant reminders via apps and sensors upon reaching unhealthy limits / engaging child in sports

A mindset and knowledge on how food impact your body is more important and basic, rather than using AI

Simulate life experiences and discomfort associated with obesity and illnesses?

Compulsory online quiz on healthy lifestyle thru school

By constant monitoring and reminders through a device and providing more details and calculation of probabilities on the consequences based on our consumption

Motivate them to exercise

Create some fun games for kids of the same interests, allow them to play together even they are strangers, Ensure their safety, without physical presence of adults. Something like the old kampong days.

Understand the amount of sugar intake for each product and total consumption for each day.

Alert the parents early and work with the parents to raise a health conscious kid together.

Measureable apps/wearable

Risk indicators and real time tracking.

Localized monitoring alerts to allow children make informed decisions on what they consume.

By simple non-invasive checks that give warnings on the 'risk ' of certain foods, calculate daily intake of sugar/ carbohydrates

Incidental messaging infused in daily media activity of child

Education videos

It will not help. TIME to exercise, prepare and eat home-cooked food is fundamental.

Affordable Electronic device to breakdown fat molecules

Get them to exercise.

A scanner that is able to Take a "live" reading of sugar, fats, etc in all the food before we eat.

Display nutrition facts real-time.

Daily exercise

Not at all, depend on your child mind set.

By tracking intake and notifying if it exceeds set limits

It is more of parents setting good examples ourselves, and turning towards healthy eating and eating more often at home. How many more things do we intend to allow technology to overrule human beings? I am also concerned about the big data on health reports on a national level.

Assessing their health, calculate exercise time, calories/nutrients for meals in a timely and convenient way.

It can track our child's diet.

Guides, Recommendations, Tracking and Follow up advices

Tracking, motivational, educational and sending reminders and useful messages

That will prompt them to live a more active lifestyle.

Tracking ability

Education and supply control

For tracking sugar intake

Track the level of sugar and calories against physical activity

Contact lenses that can monitor blood sugar levels/spike

Monitoring and advising on appropriate dietary restrictions and exercise encouragement

15. What are some factors that will motivate you to use future technology to help you reduce your child's risk of obesity?

Convenience

Ease of use

Security and privacy are ensured. Currently there are so much issues with information leaks.

Govt incentives n free tools

A nationwide effort

Free technology that's wearable n tag to parents phone

accuracy and ease of usage

My child's well-being is the driving factor.

Convenient

Easy to use

Cash rewards

School education

The easier the better

Ease of use, economical, safe

Ease of use, cost (if wearable, \$20 - 30), availability of replacements

ease of use, portability

Easier, convenient and friendly to use

Time

Wrist strap sugar detector.

Convenience, easy access and economical factors.

None. I prefer to get them to go outdoors

We are responsible for our own health. Intrinsic motivation is paramount

A user-friendly and free app in my mobile device

Help me to supervise the kids when they are not with me

Personal data on record n red flag serve as warning n reminder

The fact that I as a parent want the best for my child.

Cash bonus and free technology

Health improvements Convenience cost

Ease of use and cost effective

Genetics— dad is diabetic

Relevant information, pro activity of information

A holistic approach of school and family in managing child's health.

Simple to use.

Free, ease-of-use, non-invasive

Less cost... less everything

Convenient and easy to use. Child will not be able to remove device on her own.

Convenience and affordability

Non-invasive, minimal radiation

cost, convenience

Ease of usage / affordability

The child does not depend on it wholly.

Hereditary factors, ease and effectiveness of use

Technology at affordable prices with rewards points for redemption and also acts as motivation

convenience and accuracy

Convenience and in a healthy way

I'm already motivated. But I need to find a way to motivate my kids.

Children needs to understand the associated risks and consequences of diabetic and health problems. Educate them for young with school requiring their canteens to provide clear label of carb intakes. The child from young (primary school educators should take the lead) must

know his individual max intake per day and encourage them to be discipline. Incorporate into social science class to raise more awareness and monitor progress bi weekly with encouragement.

with rewards

Safe, non-invasive, economical.

Technology for intervention and lifestyle disruption not likely to work. Best to use tech to educate and change lifestyle that will impact risk of obesity.

Ease of usage, affordability, easy to maintain technology

Technology is part of daily interaction, and not something additional

Rewards app

Easy and economical

When fun element is Incorporated

Cost and availability of the technology

Ease of use. Privacy protection.

Ease of use, affordability

Data security and confidentiality

Dont intrude my lifestyle, affordable, wearable, convenient.

More reliable.

Popularity, effectiveness, cost

ease of use

Easy to use, low cost, effective

Ease of use.

Ease of use of device

Hassle free devices

I am already motivated

Convenient, non-invasive, accurate

Child's health

user friendliness and evidence based approach

If it is proven to be helpful

Annex B: Summary of Site Interview at Ng Teng Fong Hospital.

1. What are some of the possible challenges that you will face in the year 2030 in terms of childhood obesity and diabetes?

Lifestyle has direct implications to health. Challenge of the future include the availability of individualised devices therefore leading to a sedentary lifestyle, unless there is intrinsic motivation that can lead to a healthier habit. There is also an opportunity to use the device to turn things around with gamification and exergames.

In the old days, people engage in activities such as hunting and cooking. A lot of effort was put into such tasks and there was also times of starvation as there was no food. In those days, childhood obesity, diabetes and childhood diabetes were unheard of. Everything eaten then is fresh. Now, you can get food from vending machines and UberEats with no effort and no incidental exercise.

The Food & Beverage (F&B) Industry has a big role in affecting our choices. Instead of fresh products, food are mass-manufactured and preserved, enhancing food availability. And it is not just manufacturing but also marketing. Advertisements affects our food choices and are extremely appealing to viewers. Cheaper foods tend to be processed and thus unhealthier and that also affect people's choices.

When we look at children who have diabetes, we can segment them according to race and socio-economic status. A social worker shared this story. An overweight lady and overweight lower primary child was spotted at McDonald's and she wondered why they went there when they were already overweight. She later found out that the lady was giving her son a treat and he asked to eat McDonald's and she was only going there because it was only the only time she could afford to do so after getting a bonus. There are some issues here, she belonged to a certain demographics, kids asked for McDonald's and the food at McDonald's is cheap.

2. How do you think the fourth industrial revolution will affect childhood obesity and type 2 diabetes?

Positive

Precision medicine now, customised medicine in the future -- a tablet that is made just for you. Currently, it is only for the very rich.

AI and algorithm based robots can be used for diagnostic purposes in hospitals. This is already on trial at some hospitals. While we are training AI to ease our life and make things easier, it can also make the human lazier and reliant on the system.

Negative

In future, robots may look after children at home. This could lead to a more sedentary lifestyle, especially since there are more robots and AI doing things for us. The robot dishes out food warmed up in its body and get whatever the child wants for him or her.

In the future when AI and robot do things for us and give us more free time, how will we spend the time? Will we be motivated to exercise? Most people will play more video games.

3. If there is one problem which you think when solved, can greatly help with the prevention of childhood obesity and type 2 diabetes, what is it?

Parents definitely play a huge role in the prevention of childhood obesity and type 2 diabetes. Parents buy food for the child and can force the child to exercise.

The F&B industry. If unhealthy food is not available, you cannot eat it. The strength of the influence coming from the food industry is far too strong on the media.

4. Why do you think public education programs doesn't seem to be working in the prevention of childhood obesity and type 2 diabetes?

There are some public education campaigns that are effective. For instance, the 10000 steps campaign was highly successful. However, one has to admit that most of the public education campaigns are not successful. Firstly, this could be due to the fact that it is difficult to inculcate unhabitual things into the nature of people. Secondly, it could simply be due to the fact that the marketing strategies for the healthy food products are not as good as those for the cheap unhealthy foods. McDonald's market happy meal, it is cheap and the child gets a free toy. Brown rice, fruits and vegetables are not as easy to market and are usually more expensive. I guess the public education campaigners really have much to learn from the marketing industry but it is a very tough job. A successful campaign must be accompanied with a policy or a consolidated effort, otherwise it will not happen.

5. Have there been staff or patients who have requested or suggested future technology for use to prevent diabetes and obesity?

For pre-diabetic patients, a method to get instantaneous feedback regarding blood sugar levels etcetera without the need to pierce the skin. This will allow pre-diabetes to see what food causes high glucose level once you get the instantaneous feedback and can help in the prevention of type 2 diabetes at an early stage.

6. Is there future technology being used currently in the hospital?

In Ng Teng Fong General Hospital, there is Data-Internet separation. This means that all of the hospital's databases are all not connected to the internet. This is due to security reasons, to prevent hackers from mining the databases. Because of the Data-Internet separation, future technology is very hard to put in place in the hospital because most of this technology happens to be internet-oriented. Security is paramount for the implementation of future technology.

7. How has the app affected/ helped patients with Type 2 Diabetes and Obesity?

In the old app, users have to key in the name of the food they ate to find out how much calorie they are. With the new app, AI does it for them through photo recognition and makes it easier for the user. This is based on a huge database, which allows the app to recognise the photos of the food that have been input into the app and display the number of calories that the food contains. It also has a chat function, which allow for instantaneous feedback from dietitian to user. The app has the typical functions of its kind: calorie tracker and exercise tracker. The app is targeted at pre-diabetics, but it could also be rolled out to other patients requiring lifestyle changes.

The app so far has seen weight loss among its many of its users. This could be due to the constant reminders, as well as more instantaneous and personalised advice that was given through the app. In the days without the app, the patient has to come in every few days and the feedback is not as instantaneous.

We hope that AI can eventually take over the role of the dietitian, and allow for personalised and accurate feedback without human input for efficiency.

8. What are some limitations that your app currently faces?

Challenges faced are mostly with User Interface such as hanging. It can also be slow in the "forget password" function. As we are still training the AI, it is very good with local foods that it recognises but not so with western dishes. It is also very tedious to add more dishes to the database as at least 200 photos are required for 1 dish. It can also be difficult to stabilise the app because of the sheer amount of information and photos. When we talk about exercise, it is a tracker and limitation still exist. For instance, it is not waterproof and so swimming will not be tracked.

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