

Public Health Analytics: Three Cases Studies on a More Responsive and Effective Public Service in Australia

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Abstract

Governments around the world, including Australia, tend to develop public health policies based on data collected through rigorous surveys, such as the Australia census. Often, the data is comparatively limited compared to what private organisations have. For example, supermarkets know more about their individual customers than public agencies, information which if available to public agencies could enhance their ability to combat public health issues (e.g., obesity). In this paper, three different case studies are presented based on real-world projects undertaken in Australia. All three provides exemplars on how low-cost provision of technology and leveraging platforms such as social media can provide access to rich and timely data that may potentially contribute to better delivery of public health outcomes. While public sector surveys are generally more rigorous, the currency of the data collected quickly becomes stale for many areas of public health research and policy settings. More broadly, limited amount of such data reduces the effectiveness of public health programs. On the other hand, there are important constraints on collecting and linking data, particularly health data where individual privacy is paramount; the ethical concerns involved require agencies to examine carefully when and how data was acquired and how to make use of it. However, it is possible to point to agencies in the public sector where data linkages and the use of analytics is at a high level of maturity. In the case of public health, deciding where the ‘sweet spot’ is for data sharing and analytics is likely to require on-going dialogue.

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Abstract

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1. Introduction

Public health is one of the major concerns of public administration, given its importance as a ‘public good’ and the cost involved for government budgets. Effective ways to run public health services/systems are an on-going challenge. Public health is complex and has many layers to it, involving all levels of government. Many public health policies are developed using data that are collected from recognised and established sources, such as the Australia census (Australia Bureau of Statistics, 2020). While this approach has previously worked quite well, advances in digital technology particularly through powerful connected smartphones (Palmer & Perkins, 2012) offers new opportunities to collect and use data.

Not only have smartphones changed the way our population communicate, it has enabled an entire new paradigm of information sharing and consumption. Firstly, the population itself is now a data source and snippets of data shared through various digital platforms is enabling new ways to understand the population and its needs including in the area of public health. Compared to official surveys, a well-designed way to capture the population’s shared data

not only brings about new insights but is also “always fresh”, enabled by drawing on information as it is being shared through smartphones. Secondly, the smartphone is now a vehicle for various entities to easily and immediately reach out to most of the population in ways not possible a decade ago. In fact, many in the population have now steered away from other traditional information media (Desjardins, 2016) and are turning to interacting primarily through their phones. For public administration, this means that the “business as usual way” of engagement must change as the population evolves into a generation of “digital natives”.

The implications for public administration offices are huge (Leitner & Stiefmueller, 2019), just as organisations outside of public service are taking great advantage of this new paradigm shift. For example, supermarkets in Australia are now leaders in how they capture information from their shoppers and turning the collective data into insights through the use of “big data analytics” (Petrescu & Krishen, 2018) streamlining their supply chains, sharpening their marketing campaigns and modelling precise price points for segments of populations based on their social & economic opportunity (SEO) status, spending habits and brand preferences. Generally, the private sector has developed capabilities around data and analytics very quickly whereas, the public sector’s response to this new paradigm is patchy (Nally, 2018). In some areas of public service, data and analytical capabilities have been seriously considered and developed. In others, however, there has been a lack of investment or trials only being introduced to learn about how data from the population may lead to new ways to solve problems.

In this paper, we present three case studies from the author’s previous research in public health where data from the population and associated analytics are being used in novel ways to solve problems for citizens. In each case, we present a different angle into how a traditional problem can be addressed more effectively by leveraging the population’s use of

smartphones. We focus on the data that can be efficiently collected that were previously difficult to collect using traditional methods and show how, with suitable data analytics, the population can be actively engaged over public health issues. After presenting the three case studies relating to the use of population shared data, we discuss the potential impact and implications of digital technology in public administration. Collectively, the cases and the personal insights from the author who has worked on all three projects, provides useful guidance to leaders in the public health space.

2. CASE 1: Using smartphones to help mitigate sleep disturbance from traffic noise

A large proportion of the world's population live in metropolitan areas with noise pollution increasingly a common facet of urban living. Not many individuals are inherently aware that excessive noise can have a detrimental impact on one's sleep at night. According to the WHO, constant exposure of night environmental noise in the bedroom above 42 db(A) can lead to health issues such as hypertension, arteriosclerosis, and myocardial infarction (WHO Regional Office for Europe, 2010) and (Leao, Peerson, & Elkadi, 2012). In Australia, this is a growing issue as population growth leads to increased traffic requiring local authorities to intervene. Unfortunately, current intervention policy in Australia is based on daytime noise levels and in the state of Victoria uses a high threshold of 68 db(A) before intervention is considered. This gap of 26 db(A) is huge and is like comparing "apples to oranges" given one is daytime noise and the other night-time noise. This case focuses on the residents of the City of Boroondara, a local government area comprising ten affluent suburbs in Melbourne many of whom were making constant complaints of noise pollution impacting their sleep.

For the state authority (VicRoads) responsible for limiting road noise, dealing with night-time noise was problematic as there were no policies around night-time noise intervention, and measuring such noise pollution would require access to people's bedrooms with sound

meters deployed on a scale that would be impractical and costly. Over a number of years, residents were complaining of the worsening situation but the council relaying these to the state authorities was having no impact. In an effort to demonstrate that the council was taking the complaints seriously, it commissioned the 2Loud? project (Figure 1) to collect the elusive missing night-time data. This author was involved with the project. The 2Loud? project was a bottom-up, community driven solution. It drew inspiration from participatory sensing research (Lane, et al., 2010). Participatory sensing is a way to collect and interpret data through an individual acting alone (or in a group) using their personal devices - usually, a mobile smartphone.

In the project, residents were equipped with an app so that they could use their smartphones to collect traffic noise data measured within their bedrooms at night. Compared to sound engineering companies' methods, this approach is non-intrusive and can be done at scale. The challenge which was overcome and reported on (Ong, Leao, & Krezel, 2014), was that the smartphone solution had to be scientifically accurate so that the council had credible data to pass on to the state authorities, and residents could monitor the impact of any mitigation strategies introduced. In the process, residents felt empowered and, with information on mitigation delivered via the app, residents could also see the action taken and monitor the immediate impact.

The scope of the project was to address the noise situation from two freeways bordering the north and south corridors of some of the council's ten suburbs. In these two corridors, there are about 1000 residents who live within 100 meters of the freeway and are therefore most affected by the traffic noise. An additional 7,000 live within 250 meters from the freeway, some of whom also reported traffic noise disturbance. As resident complaints were coming from different dwelling distances from the freeways, the project focused on hotspots where noise issues seemed anecdotally more severe. These hotspots form a "band" of

dwellings along the freeway. In the north, there are 436 dwellings sitting 25m to 600m from the Eastern freeway who were near these hotspots and were invited to participate in the project through the council's communication channels (website, social media, interest group Facebook page) and a pamphlet dropped in their letterbox. The same communication and invitation were also made to the 381 dwellings around the hotspots that are 19m to 400m away from the Monash freeway in the south.

To protect the privacy of data collected from any participating dwelling, the project organized dwellings into cells (a group of nearby dwellings) so none of the readings could be identified with a particular household. This de-identification is crucial in two ways. First, aggregated data were to be shared with the community and therefore, ensuring the privacy of contributors was important to reinforce trust within the participatory system. Second, the average noise measurements taken within each cell can be compared against the individual private noise measurements of each participant thus, giving them insight into the noise insulation quality of their dwelling. This difference is only known to the individual participant and the experts, who could then look at their reported dwelling structure to subsequently provide personalized recommendations.

During the measurement phase, participants received updates from the system in two ways: the average cell noise measurement reading plotted on Google Maps as delivered in their app; and personalized feedback from experts about mitigation strategies (Figure 2). They also received support from the project team via the Website, email, phone and "on the ground" support. After the measurement phase, a report was prepared for the council about the noise situation across its two freeway corridors. In the report, noise measurements taken from participants were layered with the existing professional noise measurements and historical measurements provided by VicRoads – the local road authority for the state. A final presentation of the results was provided to the participants.

The process was radically different to how local authorities would usually have collected the data and engage with residents. In terms of collecting noise measurements, the common approach is to sub-contract the task to a local sound engineering company which would take between 3 to 6 measurements for the area covered. The results would then be provided as a report with the outcome communicated to the council, rather than residents. Even when the council communicated the results to the residents, the small number of measures undertaken were not sufficient to convince residents, many of whom live further from the freeways but are experiencing noise problems. This lack of engagement with the most important stakeholders has been a source of discontent for many residents. The project showcases the different outcomes possible when a different perspective is taken.

The project demonstrates how technology, when used with a proper design, can be a useful tool for public administration. Noise can be a subjective perception and also a relative concept. Objective measurements like db(A) often make little sense to residents whose perception of noise is often made in isolation. With this technology, all noise measurements are publicly available giving context to individuals' own noise perception. This is then augmented by on-the-ground advice and in-app provision of mitigation strategies to every resident who participated. When the 7-week project finished, a survey was conducted to see how the 68 households who participated felt about the initiative. The majority of the respondents (52%) indicated that they have a better understanding of noise and their environment and about half (48%) felt that the mitigation strategies provided were useful to them. These positive but less than overwhelming responses may reflect lack of confidence in the state authority taking adequate action. In the same survey, the council also learned that almost 9 in 10 would still expect the local authorities to act on their noise concerns.

3. Case 2: Using smartphones to develop data for personalised intervention of feeding methods in infants to prevent obesity

Strategies to prevent child obesity have conventionally focused on older age groups when the child is already overweight or obese. In Australia, 20% of pre-school children are overweight or obese. While birth weights have remained fairly stable over recent decades, the number of obese pre-schoolers is on the rise. These observations suggest that prevention should begin much earlier (Wake, Hardy, Canterford, Sawyer, & Carlin, 2007) with a focus on the first few years of life to establish healthy patterns of growth (Baur, et al., 2010).

During this period, particular feeding behaviours are associated with obese infants. Fortunately, these behaviours are modifiable. In particular, formula feeding, feeding beyond satiety, adding cereal to bottles, using feeding as a method of soothing, putting a baby to bed with a bottle, and early introduction of solids are candidates for intervention (Gibbs & Fortse, 2014). While maintaining or increasing the duration of breastfeeding has many benefits and remains a public health priority, many women wean their babies early, making bottle feeding practices an important target of intervention if obesity risks in children are to be reduced.

In countries like Australia, UK and the USA, it has been observed that children from socioeconomically disadvantaged families have higher rates of obesity compared to children experiencing less disadvantage. As reported in the longitudinal study of Australian children (Wake, Hardy, Canterford, Sawyer, & Carlin, 2007), those preschool children in the highest quintile of disadvantage indicators are nearly 50% more likely to be overweight or obese compared to the most advantaged children. More concerning is that the socioeconomic differentials present in those children at four to five years of age had more than doubled by the time they reach between ten and eleven years (Jansen, Mensah, & Nicholson, 2013).

The cause for this higher rate of obesity among socioeconomically disadvantaged families are complex and multifactorial but studies have identified predictors of child obesity in early

life that are more prevalent in socioeconomically disadvantaged families. These predictors include (i) higher rates of formula feeding; (ii) early introduction of solids; (iii) unhealthy infant feeding practices; and (iv) poorer diet (Wake, Hardy, Canterford, Sawyer, & Carlin, 2007) . The key message from these findings is that children from socioeconomically disadvantaged backgrounds have a higher exposure to obesity promoting environments. Therefore, they are in greater need of support to establish healthy behaviours early in life.

While it is known that early preventive efforts should be directed at socioeconomically disadvantaged families, the most effective approaches for reaching these families are unknown. Primary health care services, including maternal and child health services, and general medical practice (e.g., family doctors) are frequently visited by parents across a broad socio-economic spectrum. While practitioners report a high level of interest in obesity prevention among parents, they also noted a wide range of barriers to deliver that support to parents which may vary with socio-economic circumstances. These includes system level barriers (e.g., the lack of time, remuneration, support staff, appropriate resources and programs for referral), attitudinal barriers (e.g., concern about parental reactions, discomfort about raising the issue), and a lack of knowledge, skills and training in the area (Hearn, Miller, & Cross, 2007; McMeniman, Moore, Yelland, & McClure, 2011; Vine, Hargreaves, Briefel, & Orfield, 2013; Robinson, Denney-Wilson, Laws, & Harris, 2013).

Interestingly for countries with high penetration of wireless technology (Australia included), income has not been a predictor of mobile phone or smartphone ownership (Australian Bureau of Statistics, 2016). Furthermore, (Buultjens, Robinson, & Milgrom, 2012) found evidence to suggest that parents these days turn to the Internet and apps for information on infant feeding. This led to the development of the Growing healthy program, the focus of this case study, with the aim of using technology to deliver high quality infant

feeding resources; as well as timed and targeted interventions through push notifications, text messages and personalised emails.

For many researchers in this area, m-Health or tele-Health is a popular arm of IT-health research looking to leverage technology to improve intervention outcomes. The primary advantages with this approach are the potential for greater cost effectiveness than face-to-face interventions when the scale of the intervention is large. And through technology, the intervention can also be delivered with high availability, offering its participants 24x7 availability while for the researchers, the opportunity to build a technology platform that results in a data-rich environment to deliver better intervention.

The project started in 2013 and, in its first version, was called the “Growing healthy” program. The app’s first version included professional health advice, allowing participants to consume the information while receiving interventions in the form of weekly emails, text messages and push notifications designed around the baby’s age. The aim, as noted above, is to provide timely information to parents to help them with their feeding patterns and ultimately alter the carer’s behaviour to achieve the intended intervention comes. The baby’s age was used in the first version to understand when to provide relevant information to the participants, such as the right time to transit the infant over to solids, or to encourage breastfeeding over formula feeding in the first trimester following the baby’s birth.

The project was also set up to collect extensive data, including demographic information about parents so as to deliver a personalised program to them. In the initial study, the aim was to understand and ascertain if mobile-based health (or m-Health) intervention of this nature would work, so a large amount of additional information was collected to allow researchers to understand engagement over time. The researchers took the opportunity to explore engagement in a deeper way, as there were no such studies at the time. This multi-faceted approach to understanding engagement led researchers to understand what works and what

doesn't. The first version of the app showed a drop off in engagement over time in every aspect measured (Figure 3). Notably, people stopped returning to the app after the first trimester of the baby's birth and therefore, the interaction with the app also dropped.

Interestingly, however, the weekly interventions managed to deliver a higher engagement score than the app itself, suggesting that timeliness of information is very important and, when the information is personalised and targeted, people will respond. This was shown in the analytics from the click-depth and interaction index. The interaction index looks at the number of push notifications opened while click-depth measures in part the exploration taken by the participant after 'encouragement' from the push notification or email they received over the week.

With this understanding, the team developed version 2 of the app, which was renamed "My Baby Now" (Figure 4), and is supported by a National Health and Medical Research Council (NHMRC) Partnership Grant from 2019 – 2023. The app took the learnings from Growing healthy and redesigned an app that is not simply a content provider but has added utility and interactivity. The first change is the inclusion of a 'new feed' and a social forum within the app inspired by the design of social media apps. By incorporating interaction and participation from other parents, the app is now an information store, creating a community of users that was not included in the first version of the app. To improve utility and thus encourage participants to use the app, new tools such as a formula calculator and a vegetable tracker (to encourage more greens in solids) were introduced in the app.

With these added features, the health researchers also redesigned the intervention mechanism, with more personalisation and targeting, adding not just information on feeding and strategies to reduce obesity but also interventions to encourage infant play and engagement with participants before birth (pregnancy). The analytics were also improved, allowing multi-dimensional exploration of the data using interactive dashboards produced for

m-Health research consumption as shown in Figure 5. Furthermore, the app is now being enhanced to include the use of machine learning and AI to further improve the app's utility and to continue to increase engagement with participants. This includes a bot to participate in the forum conversation of the app, and a new tool to help parents understand baby skin conditions with a simple camera shot of the baby skin, with advice provided by machine learning using deep learners (Figure 6).

4. Case 3: Understanding population health from social media

In this last case, we turn to a common problem faced by many public health researchers, that is, the lack of relevant and current data to address the problem at hand. This challenge is worth looking into from a different angle as we are seeing increased cases of public health stakeholders raising concerns around outdated or lack of data for use in public health policy settings. We experienced this when addressing two separate problems coming from a diet intervention research group and from multiple service providers operating Australia's National Disability Insurance Scheme (NDIS). We shall first outline the issue and then contextualise this to the two problems that we are investigating so that readers can understand the significance of this issue.

For many public health researchers, a chief source of data would come from well-curated sources such as the Australian Bureau of Statistics (ABS). As an example, one of the largest quality data collection exercise undertaken by the ABS is the national census, where the data is only collected every 5 years though via a systematic and rigorous process. It aims to capture a snapshot of the whole Australia population, encompassing a wide range of questions about the population to inform a wide range of policy settings, including public health. The approach has considerable merit and is highly useful to government agencies and other stakeholders. For some stakeholders however, such data has limitations, including its

limited freshness (Carey, et al., 2019), particularly when the population profile is changing quickly due to migration and other factors. As a result, not all stakeholders find the ABS census and other survey data useful or reliable if their role is to undertake planning or service delivery in regions such as the growing outer-metropolitan areas. In addition, some stakeholders are concerned about forward planning and the need for information to help predict future developments. Such information may be held by various government agencies but the lack of sharing data amongst agencies due to concerns of privacy etc. is limiting the ability of non-government service providers to draw on the data in order to deliver better targeted and more responsive services to the public. As a result, needs may not be appropriately met and resources, some funded by the taxpayer, may be wasted.

In the context of the diet intervention research group, one of their goals has been to deliver interventions to address obesity and heart health. For dietary data, the challenge is not just with stale government data but also the very lack of data because of collection difficulties. Yet commercial organisations have relevant big data (Arnold, 2019) about what their customers buy at the grocery, or what they order through delivery apps, such as Menulog or UberEats. For commercial organisations, the objective is sales, which might seem at odds with the goals of government health agencies, such as the National Heart Foundation or VicHealth.

To overcome this, it was proposed that we examine whether there are data available from non-official sources that can, with some form of analytics, facilitate better understanding of diet patterns, food choices, or food interests, and whether such data might be sufficiently timely and relevant for public health agencies. The preliminary test case focused on social media, mainly with Twitter, Instagram and YouTube. The research team was interested in finding out if social media is capable of providing up to date clues about the general population's food choices. The test case specifically looked at "healthy cooking" on

YouTube, harvesting over 1,500 videos on “how to cook healthy”. The initial findings suggest it is indeed possible for the public health sector to use the same technology to combat the “sales-driven” analytics of commercial organisations.

The study found that, among the population interested in making a healthy meal, there are common ‘concerns’ about which dietitians could provide suitable advice and minimise the tendency to go for easy to access but not always well-informed solutions from food apps. The YouTube video study revealed that many in the population are interested in cooking well for breakfast and dinner, the two meals in the day that can be done at home (Figure 7). For example, many are interested in finding ways to cook delicious steak or broccoli as a healthy meal for dinner. In the case of preparing a healthy breakfast, many Australians are interested in ways to produce a good oat-based breakfast, or how salmon can be incorporated into their breakfast diet. These findings were discussed with dietitians in the research team who found that these findings support some of the more rigorous research studies undertaken in the past. This is encouraging as the premise of the study was to ascertain that social media data could be a reliable alternative to understanding the population’s diet. If so, it could give dietitians access to up-to-date data for many of the problems they are trying to address, giving them an opportunity to be more effective in providing advice.

Similarly, providers of services funded under the National Disability Insurance Scheme (NDIS) that we have been in contact with have been designing their services around the population data from the ABS only to find that their community profile didn’t fit. Consequently, this led to a waste of taxpayers’ funds as incorrect health professionals and medical supplies were procured. Worse, the communities they serve were felt let down by their providers because of inadequate access to services. Over time, this has led to an unwillingness among providers to make investments for fear of making losses arising from mismatch of service to local community needs. The need for data-driven planning has led to

providers turning to universities for solutions to acquire the data they need. While a formal project is being scoped, similar proof of concepts has been undertaken to test if social media platforms could be a solution to the lack of data.

For many providers, the services they deliver is to the local community, so knowing the demographics and being able to develop a profile that matches research findings will help identify the kind of services that is required, and how those services can be provided to achieve the best outcome. In our preliminary work to test this possibility, a group of Analytics students developed code to harvest Twitter feeds with the ‘#ndis’ hashtags that is then analysed using sentiment analysis, a predictive model that analyses text and assigns a score indicative of positive or negative sentiments. Tweets that were deemed to be of negative sentiment were grouped around the location information found in their profiles to give an idea of the concerns that are found within that specific local community. While there is further work to be undertaken, the provider who commissioned this project saw potential in the tool and the use of social media data to help augment their planning process.

In both these examples, the challenge is real and it is likely to be a common problem shared by other areas in public health as the world we live in moves at a faster rate of change than ever. Even though the results were preliminary for both these examples, they suggest considerable potential from mining social media to improve the effectiveness of public programs.

5. Conclusion

The three case studies presented were initially conducted purely as academic exercises by public health scholars addressing particular public health issues. But together they reveal opportunities for enhanced public administration across the public health field. The projects were undertaken between 2013 to the present, and the technology landscape over this period

has changed dramatically. Governments around the world are facing new challenges and technology is playing a major role in disrupting well-understood models and paradigms. The cases demonstrate that new technology can breakdown some of the barriers that limit the usefulness of existing official data collections, not only improving the amount and timeliness of data but also creating greater accessibility to the public, informing them, delivering services, and gaining insights.

In CASE 1, the liberation of information through technology has helped a local council deliver a genuine and substantial response to public health concerns of its residents. It was able to demonstrate the council's responsiveness to residents and to press the responsible state authority to act, when the local council has no direct responsibility for the problem. With CASE 2, the provision of new services through technology has helped local health authorities address an important public health problem in a cost-efficient manner and at scale. It also demonstrates how the particular health problem develops and how the public can be engaged to identify effective government solutions. Also, influenced by other digital services, the public expectation of service delivery has moved to an "on-demand" and "personalised" response. Thus, public administration must start to think differently, in terms of how it engages with its community taking into account the changing way the community lives, works and plays.

The challenging shift required in public administration is perhaps best demonstrated in the exploratory CASE 3, which suggests that the effort to combat public health issues now requires a change in thinking and approach. Timely data that facilitates effective responses to individual circumstances and preferences requires access to non-official sources of data and the adoption of new technology and private sector practices that allow engagement with the public. This may also require acceptance in the public sector of the quick 'test and fail'

approach often used in the private sector. At the same time, such approaches can raise important ethical issues such as privacy protection and proper accountability.

Technology will continue to have a major impact on public administration. It will be a double-edged sword that can better meet community expectations while also putting more pressure on public administration offices to respond. In Australia, different public service offices have varying levels of success in deploying technology and in introducing paradigm shifting approaches to address problems. The varying degree of success among public administration offices hinges on many factors and is likely a complex one. The case studies presented in this paper will, hopefully, help to continue the discourse in the area of public health.

Figures



Figure 1: The 2Loud? project was a project built around the use of technology to disrupt traditional approach of data gathering and to enable new ways to engage with its population. The novelty of this approach has led to the project being featured by the European Commission for Science for Environment Policy.

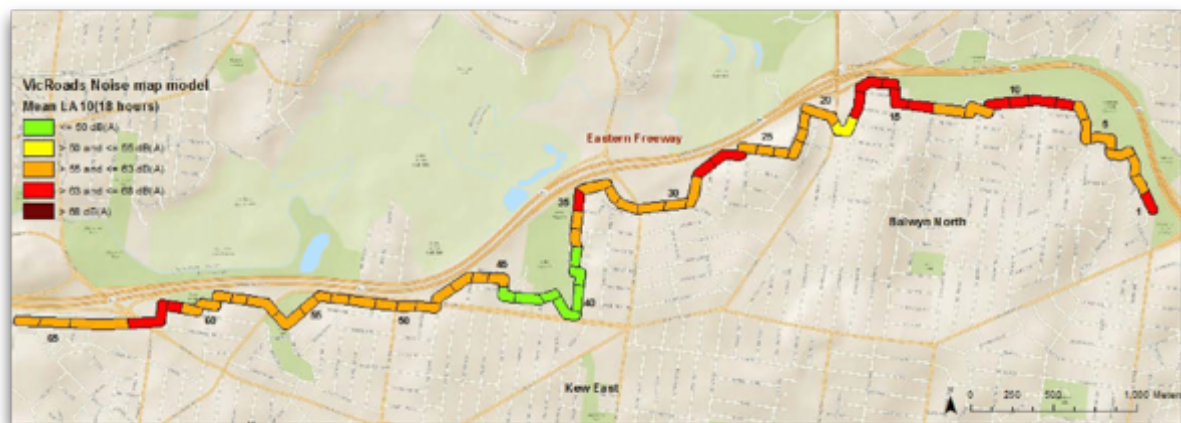


Figure 2: The measurements from different households are mapped into ‘cells’ giving everyone an idea of their own situation without disclosing individual specific dwellings. This was a major feature of using the technology to (i) enable a measurement that would be difficult to undertake at night time by a contractor; (ii) deploying measurements on such a large scale and with this high degree of fidelity; and (iii) giving participants instant feedback and context never done before by local authorities using traditional approaches.

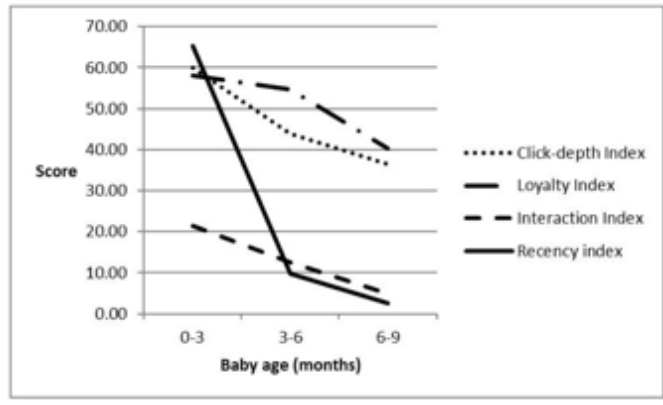


Figure 3: The frequency scores for various engagement analytics measured in the first version of the project, over the three 3-month period of the baby’s age following his/her birth.

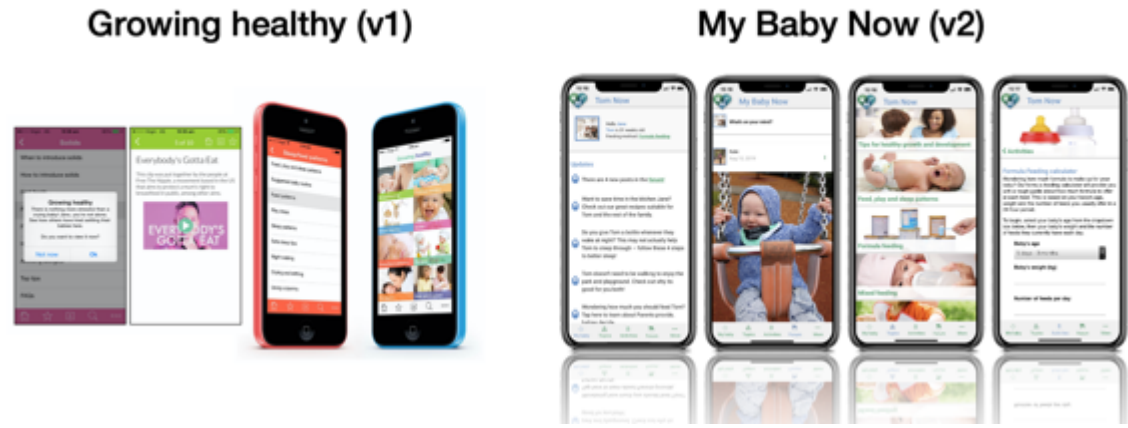


Figure 4: On your left, the first version of the app (called Growing healthy) for large scale obesity infant feeding intervention, which was offered from 2013 – 2015. On right, the second version of the app and renamed “My Baby Now”, with more advanced data analytics used by researchers to deliver interventions.

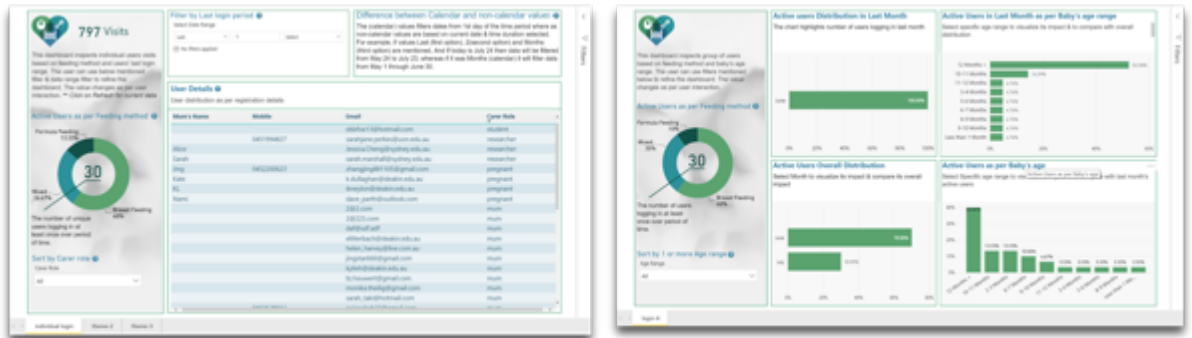


Figure 5: Some of the dashboards produced for the maternity child health researchers to understand how the participants of the intervention programs are engaging with the app. The system also allows researchers to then tailor different messages based on the analytics to ensure first-time mums are getting the most out of the programme.

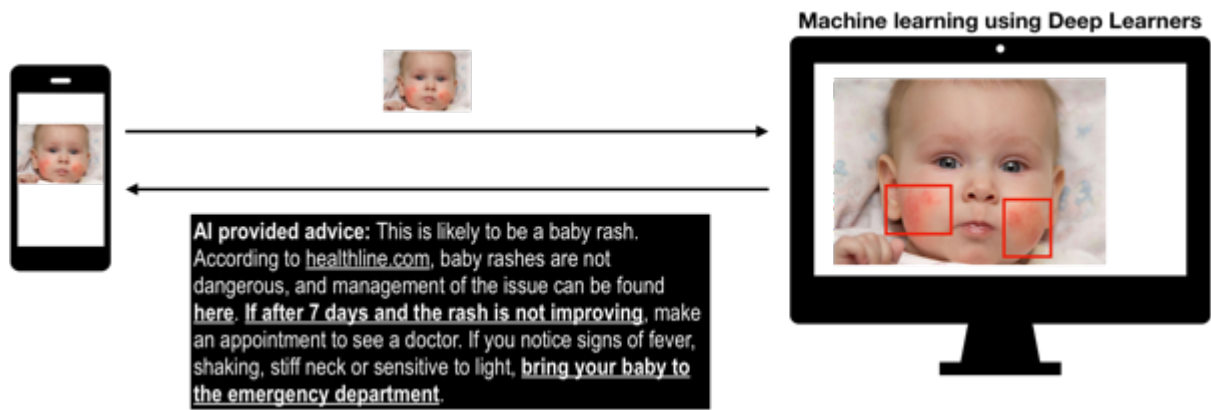


Figure 6: This tool, incorporated into the My Baby Now app, showcases how technology can effectively reduce the burden on the health system by allowing the population use the app to easily get basic advice.



Figure 7: Analysing over 1,500 YouTube videos based on the search term “healthy cooking” shows that the population is predominantly interested in cooking for breakfast and dinner. In the case of cooking dinner (figure on left), we found from the analysis that broccoli and steak were of top interests for the Australian population. Whereas in the case of making a good meal in the morning, it appears that many Australians are interested in how to prepare a good oat-based breakfast, or one that involves salmon.

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