Subjective Decision-Making in Healthcare: The Case of Vaccinations

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Abstract

Although an understanding of socio-scientific issues is purported to influence and inform individuals' behavior and decision-making, this may ultimately depend on the level of control any person feels they have to enact change. Current major issues such as global warming and consequent climate change or the production of genetically modified foods, may well appear to be out of the control of individuals. Consequently, people may look to the government to enact legislation to deal with these. However, one area where individuals have almost total control, in most western societies at least, is that of vaccination. In this study, 33 university graduates (largely university lecturers) from science and non-science backgrounds were interviewed in an attempt to ascertain their attitudes to vaccination programs and to determine where they obtained their own information from in relation to vaccinations. The small sample of this inquiry precludes generalisation. However, the preliminary findings indicated that in general, background (science or non-science) did not appear to be a determinant of support for vaccination programs, and although both groups drew on a wide range of information sources about vaccination, the most common sources of information cited by the participants included general practitioners or health care workers. Furthermore, despite being aware of some side effects, they generally had high confidence in vaccine safety.

Introduction

Rapid scientific and technological change has presented society with new dilemmas such as climate change, reproductive technologies, genetically modified foods and vaccination (Saunders & Rennie 2013). These complex socio-scientific issues (SSIs) also appear in the media regularly and many are of direct relevance to the general populous. It requires a certain level of scientific literacy on the part of citizens to interpret and make informed decisions about such issues. Goodrum, Hackling and Rennie (2001) have suggested that scientific literacy should be an aim of school science education to help students to make informed decisions about the environment and their own health and wellbeing. However, this recognized need for a scientifically literate citizenry must be reflected in curriculum and policy documents, and recent shifts in science curricula in Australia (the context of the present work) reflect this increased focus on scientific literacy. The new National Curriculum in Australia has a strand titled "Science as Human Endeavour" (SHE) which addresses SSIs (ACARA 2015). The sub-strand titled use and influence of science within SHE clearly states that this aspect of the curriculum:

> *…explores how science knowledge and applications affect peoples' lives, including their work, and how science is influenced by society and can be used to inform decisions and actions* (ACARA 2015; p. 9).

The degree to which reporting of SSIs in the media may influence an individual's behavior and decision making, may well depend on the level of control any person feels they have to enact change. For example, people with specific knowledge of the science and/or background of a topic like vaccination were more confident in making judgements about whether to vaccinate or not (Çalik & Coll 2012). Current major issues such as the reported increase in global warming and predicted climate change or the production of genetically modified foods, may well appear to be out of the control of individuals, meaning they 'tune out' or fail to engage in much discussion. Consequently, people may look to the government to enact legislation to deal with these. However, one SSI where individuals have almost total control, in most western societies at least, is that of vaccination. Vaccination policies in different countries are quite varied with some governments choosing to educate their populace and leave the choice to individuals and others that have made vaccinations mandatory (Walkinshaw 2011). Many, countries with mandatory vaccination policies opt not to enforce them (Walkinshaw 2011), which may suggest that there is an expectation that everyone will follow the policy. Many individuals being vaccinated are young children, who cannot make this decision themselves, so that decision falls to their parents. Hence, it is of interest to know parental and adult attitudes towards vaccinations.

Child vaccination rates for diseases such as diphtheria, tetanus, pertussis and measles in most western countries are generally over 90% (OECD 2018). However, the process of mass vaccination is still viewed as controversial by certain interest groups within society. Furthermore, issues such as the recent outbreaks of Ebola in West Africa and the Zika virus in Latin America, and the search for appropriate vaccines to counter these, tend to keep the topic of mass vaccination programs in the news. For example, Brazil was suffering a significant outbreak of Zika prior to hosting the 2016 Olympics, which made international headlines.

This study explores the views of a group of tertiary educated individuals at an Australian university with science and non-science backgrounds on the topic of vaccination and more specifically mass vaccination programs and attempts to draw some tentative conclusions about what might influence these views.

Scientific literacy

Individuals need to be scientifically literate if they are to engage effectively with an SSI such as mass vaccination. Scientifically literate individuals have knowledge of science content as well as some knowledge of science evidence claims (Dillon, Coll & Taylor 2009). However, according to Smith, Loughran, Berry and Dimitrakopoulos (2012), there has been a contentious history over what constitutes scientific literacy. Initial definitions included a comprehension of scientific information and later included the ability to apply scientific ideas to real life problems (Yore, Hand & Prain 2000), while Young, Cole and Denton (2002) argue that scientific literacy should provide individuals with the tools to participate intelligently and thoughtfully in the world around them. More recently McKinnon and Vos (2015) have put forward a description of a scientifically literate individual that is perhaps more in keeping with this current research. They are that a scientifically literate individual will have an interest in science, understand the world, engage in science and think critically about scientific matters. They believe that literacy requires at some basic level an understanding of science content, engagement with science and certain attitudes about science, like interest or skepticism.

However, regardless of definitions or descriptions, Gregson (2018) makes the point that the learning of science today goes beyond the reading of textbooks and individuals' cognitive ability to understand a myriad of scientific concepts. The increasing use of the internet as a source of information exposes individuals to a very wide range of resources, that not only need to be read and comprehended, but also critiqued for their value and relevance to the concepts under consideration. As such, to be effective, science education must develop skills of critical thinking if individuals are to make well informed choices in the face of a substantial amount of often conflicting information, particularly when considering SSIs such as vaccination where individuals can actually exert some control at a personal level, but where that choice might ultimately have societal consequences.

Within Australia, the context of this study, a national survey of scientific literacy commissioned by the Australian Academy of Science and published in May 2013, indicated that although most Australians had a basic grasp of key scientific facts, there were still large numbers who answered important and fairly straightforward scientific questions incorrectly (Wyatt & Stolper 2013). Furthermore, a recent review of scientific literacy more globally, but with specific reference to developing countries, argued that there was a particular need to improve science literacy in developing countries where recognition and adoption of coherent policies remains sporadic and lacking cohesion. This was seen as especially pressing in certain areas of health (Davies & Priestly 2017). Thus, it seems that globally and within Australia, there are limitations to scientific literacy that may limit individuals' ability to critically engage with SSIs.

Mass vaccination –successes and controversies

There have been numerous advances in medical treatments worldwide over the last 50 years, with extraordinary successes in the eradication of diseases previously resulting in the deaths of many millions of people (Andre, Booy, Bock, Clemens, Datta, John, Lee, Lolekha, Peltola, Ruff, Santosham & Schmitt 2008). One of the most significant of these advances has been the development of vaccines to counter a range of viral and bacterial diseases, many of which are fatal or extremely debilitating. Vaccination reduces morbidity and mortality thus helping economic growth. Andre et al. (2008) report the annual return on investment in vaccination to be between 12% and 18% in terms of reduced health-care costs. Ehreth (2003) estimated that vaccines annually prevented almost 6 million deaths worldwide, and in economic terms this translated into direct savings in the order of tens of billions of US dollars globally. Arguably one of the most successful vaccination programs is that which led to the eradication of smallpox and type 2 polio, the former of which WHO estimates saved over 300 million lives. Furthermore, by reducing the need for antibiotics, vaccines may reduce the prevalence and hinder the development of resistant strains, one of the most challenging problems facing the world today (Andre et al. 2008).

Paradoxically, in spite of the well-documented success of vaccination programs against formerly fearsome diseases that are now rare in developed countries, vociferous anti-vaccine lobbies still thrive today (Andre et al. 2008). One might argue the eradication of previously fatal diseases by vaccination has led to complacency. An example is the anti-vaccination lobby group Australian Vaccination-Skeptics Network (avn.org.au), formerly known as the Australian Vaccination Network (AVN), until forced to change its title by an arm of the Australian government. It has lobbied strongly against a variety of vaccination-related programs, downplayed the danger of childhood diseases such as measles and pertussis, championed the cause of alleged vaccination victims, and promoted the use of alternative medicine such as homeopathy and chiropractic for which there is no consensually agreed

scientific evidence of efficacy. There are concerns globally that the 'anti-vax' movement as it is known collectively, is influencing parental choice negatively against vaccinations to the extent that in some areas it is falling below what is termed 'herd immunity'. This is the level of immunity at which it is improbable that a disease can spread. Optimal herd immunity is provided by vaccination rates of 90% for most vaccines but higher coverage rates of up to 95% are required for others such as measles (Fine & Mulholland 2008). In 2015, the British Broadcasting Corporation (BBC) reported that in Seattle, Washington, in the United States, 80 to 88% of children are immunised for polio, meaning that polio may theoretically re-emerge in Seattle because insufficient numbers of people are being immunised (Hes 2015).

The influence of the anti-vaccination movement was given enormous impetus in the early 2000s when research by Dr Andrew Wakefield of the Royal Free Hospital in London, was published in the highly reputable medical journal, The Lancet. This research suggested a link between the Measles Mumps and Rubella (MMR) vaccine and autism, and although later discredited, it did raise significant concerns about the safety of the MMR vaccination amongst the general populace of the United Kingdom in particular. This led to a drop in the rates of MMR coverage in Britain and elsewhere (Bloom, Canning & Weston 2005). The consequences of this fall in coverage were experienced later, when in 2013, the Department of Health launched a national catch-up vaccination campaign in response to a rise in measles cases and an epidemic in Swansea in Wales (Iacobucci 2013). This was mostly attributed to unprotected 10−18 year olds who were not vaccinated in the late 1990s and early 2000s (Wise 2013).

In a number of countries there are now calls to ban unvaccinated children from attending school because of the risk they pose to others and the possibility of a resurgence of previously well-controlled diseases. On 1st January, 2016 the Government of the State of Victoria in Australia took the step of banning children from attending childcare or kindergarten unless they are fully up-to-date with their immunization schedule (Victoria State Government 2016). The New South Wales parliament passed a similar amendment to their public health act from the 1st January, 2018 which bans unvaccinated children from being enrolled in childcare facilities (NSW Government 2017).

Role of the media

As with many controversial issues in science, the role of the media is often pivotal in influencing public opinion (Leask, Hooker & King 2010). For example, Mason and Donnelly (2000) reported that a protracted campaign against the MMR vaccine was run by the South Wales Evening Post (SWEP), an evening newspaper sold in parts of two Health Authority areas in Wales. Their study compared MMR uptake in that area of distribution with uptake in the rest of Wales. They found that although a drop off in MMR vaccine uptake occurred in the whole of Wales, there was a statistically significant greater decline in the distribution area of the SWEP (Mason & Donnelly 2000). Furthermore, a survey by Cardiff University at the time of the MMR 'controversy' claimed that more than half of the British public wrongly believed that medical science opinion was split down the middle on the subject. This may be because as Mooney (2004) argues, in its most simplistic version, journalistic objectivity means that both sides of an issue should be balanced against one another. But this argument collapses when it comes to scientific issues, as science is not a democracy, and in practice one side of any scientific debate is often much more supported by evidence than another. Findings that have been peer-reviewed, published in leading journals and replicated or confirmed by other scientists have much stronger weight attached to them.

This example highlights one of the key problems with media reporting on vaccination and other issues, that giving equal voice to scientists (and indeed often non-scientists) on both sides makes it seem like there is a serious disagreement within the scientific community, when in fact this is often not the case. llman (2013) has argued that scientists over-estimate the power of statistics in mass communication. He went on to say that individuals who read a short emotional article about a topic are much more likely to be swayed by this than raw statistics on the general topic. Thus, the facelessness of statistics, one of the great strengths in science, can ironically be an abject failure in mass communication. Furthermore, case histories make better reading than statistics but fail to reflect the extremely low risk probabilities involved with a process such as vaccination. They also tend to increase the perception that risk is significantly greater than in reality. Additionally, journalists may rely more on "anecdotal instead of statistical evidence; expert testimony rather than publications; emphasise controversy rather than consensus; and represent issues in terms of polarities rather than complexities" (Nelkin 1996).

Thus, although case-control studies demonstrated no link between the MMR vaccine and autism (DeWilde, Carey, Richards, Hilton & Cook 2001; DeStefano, Bhasin, Thompson, Yeargin-Allsopp & Boyle 2004; Smeeth, Cook, Fombonne, Heavey, Rodrigues, Smith & Hall 2004; Price, Thompson, Goodson, Weintraub, Croen, Hinrichsen, Marcy, Robertson, Eriksen, Lewis, Bernal, Shay, Davis & DeStefano 2010), and two meta-analyses found no associations between exposure to MMR vaccine and autism (Taylor, Swerdfeger & Eslick 2014; Yoshimasu, Kiyohara, Takemura & Nakai 2014), the public were unlikely to be aware of these studies and were more likely swayed in their thinking by media articles reporting anecdotal 'evidence'. Such skepticism in the public may have been exacerbated by well publicized failures of the scientific community on some high-profile SSIs, such as thalidomide and the so-called mad cow disease. In these incidences, the scientific community closed ranks, denied reality, and were subsequently exposed.

Studies on attitudes to vaccination

There have been a number of studies and systematic reviews on attitudes to vaccination and what influences these as well as the reasons related to vaccine hesitancy, particularly among parents (Rainey, Watkins, Ryman, Sandhu, Bo & Banerjee 2011; Sadaf, Richards, Glanz, Salmon & Omer 2013; Larson, Jarrett, Eckersberger, Smith & Paterson 2014; Yaqub, Castle-Clarke, Sevdalis & Chataway 2014). These studies have reported a range of factors that influence attitudes to vaccination. These include parents' belief that the disease is not serious or is uncommon, that other methods such as homeopathy are preferable to vaccination (Bedford & Elliman 2000) and that the vaccine is ineffective or unsafe and may cause adverse effects due to particular ingredients such as mercury (Nicholson & Leask 2012). Other influences on parental attitudes to vaccination, particularly in low and middle income countries, include religious or traditional beliefs against vaccinations, low education level of primary caregiver, lack of knowledge on role of vaccinations and disease prevention, being a female child and mistrust of health care systems (Rainey et al. 2011).

Studies on attitudes to vaccination are largely, although not exclusively (Brunson 2013; Hilton, Patterson, Smith, Bedford & Hunt 2013), large-scale quantitative surveys, the findings of which allow for generalizability (Kahn, Rosenthal, Hamann & Bernstein 2003; Timmermans, Henneman, Hirasing & van der Waal 2005; Hak, Schönbeck, De Melker, Van Essen & Sanders 2005; Mergler, Omer, Pan, Navar-Boggan, Orenstein, Marcuse, Taylor, deHart, Carter, Damico, Halsey & Salmon 2013). Such studies provide broad insights into attitudes towards vaccination and the factors influencing these. On the other hand, a qualitative study may

generate valuable insights into emotional experiences that influence people's personal attitudes towards vaccination and provide a rich and in-depth perspective on this issue (Giacomini & Cook 2000; Forster, Rockliffe, Chorley, Marlow, Bedford, Smith & Waller 2016). As such, the purpose of this study was to gain a deeper understanding of what shapes and supports attitudes towards vaccination among a group of university educated participants from science and non-science backgrounds, and if possible to determine if training in science, and thus potentially greater scientific literacy, might result in better understanding and more positive attitudes towards vaccination and vaccination programs.
The research questions informing this study were:

- *What are research participants' attitudes towards vaccination programs?*
- *What are research participants' understanding of the process of vaccination and how it works?*
- *What factors influence decisions about vaccination uptake?*
- *Where do research participants obtain their information on vaccinations?*

Context of the study
This study was undertaken in Australia, a country with a population of approximately 25 million people. Large areas of the centre of the country are extremely arid and have very limited population as a consequence. In fact, Australia is one of the most urbanized countries in the world with about 90% of the population living in large settlements mainly on the coast. The country is considered to be multicultural but the majority of the population, around 85%, is of European ancestry with around 12% from Asian ancestry (South & East Asia). Australia has high levels of education and an excellent health system with a life expectancy of 82. It is also a wealthy country with a per capita income of approximately US$50,000.

Method

A qualitative methodology was adopted in this study using one-to-one in-depth interviews to explore the richness and variation in individual participants' perspectives. The study involved a purposeful sample of 33 secondary and tertiary teachers (19 females & 14 males) (Table 1). All participants were tertiary educated with 17 listing their area of formal educational qualification as science and 16 listing it as non-science. The sample and nature of this inquiry precludes generalisation; the intention here is to use qualitative means of inquiry to provide an in-depth understanding of complex issues (Guba & Lincoln 1994).

Ethical approval was gained from the University of New England Human Research Ethics Committee: Approval number: HE17-007

Table 1: Participant information

Number of Participants	33 (19 Females; 14 Males)
Area of Formal Qualification	Science: 17
	Non-Science: 16
Age Range	
20-30	1
31-40	5
41-50	10
51-60	10
61-70	7

The participants had qualifications in a range of areas which included:
Maths, Physics, Chemistry, Biology, Spatial Sciences, Inclusive and Special Education, Educational Context, Literacy, Art, History, English Literature, Botany, Ecology, Environmental Science, Social Science, Soil Science and Study of Languages other than English.

Interview protocol
Each participant was presented with an information sheet about the research project and subsequently signed a consent form. The interviews were conducted by the first two authors and lasted approximately 12 -15 minutes (interview questions are provided in supplementary material). All interviews were audiotaped and transcribed verbatim. The interviews were semi-structured and comprised of general questions about participants' understanding of vaccinations and how they work, the ideas they considered before making decisions about whether to be vaccinated or not, whether they had any fears or concerns about vaccinations, where they got their information on vaccinations, whether they supported national vaccinations programs and the reasons for their answer.

Data analysis
The interview transcripts were imported into *NVIVO v.11* qualitative software (QSR 2015). Analysis was informed by the interview questions and coding was undertaken by the first author. Initial codes were identified and further categories were detected from these in an iterative process, which captured:

- Participants' attitudes towards vaccination programs
- Participants' understanding of the process of vaccination and how it works
- Factors that influence participants' decisions about vaccination uptake
- The different sources of information on vaccination used by participants

The second author reviewed all transcripts independently and themes were discussed and revised. There were some inconsistencies and ambiguities, which were resolved through discussion. All quotations below are reported using pseudonyms.

Findings and discussion

Attitude towards vaccination programs and understanding of the vaccination process
The dominant theme to emerge from this study was one of support for national vaccination programs regardless of academic background (Table 2).

Table 2: Participants' attitudes towards mass vaccination programs

Attitudes towards national vaccination programmes	Number of respondents
Ambivalent	2
Negative	0
Positive	31

Thus, of the cohort of 33 participants only two individuals (both non-scientists) seemed ambivalent towards vaccination programs, but even they did not express outright rejection of such programs. The most cited reason for the widespread support was that such programs were important for the eradication of previously common diseases like polio and smallpox. Other reasons given were that national programs:

- make vaccination affordable and accessible for everyone
- are important for maintaining immunity in the broader population (herd immunity)
- save the health system money in the long term
- provide the best chance of national coverage compared to if programs were local
- provide broader benefits to society by not bringing preventable diseases back into the community

The reasons identified in this study may reflect the well-educated backgrounds of the study participants, most of whom had a clear scientific understanding of the process of vaccination and how vaccines were meant to provide protection. This was true of participants from both science and non-science backgrounds.

Anne, a language specialist and a parent, was a keen advocate of vaccination programs and appeared to have an understanding of how vaccines function:

> *My understanding of vaccination is that you are introducing very small amounts of a certain strain or virus that you wish the body to create antibodies to. For that reason, you're having your children or yourself vaccinated so as to avoid having a full-blown case of whatever it is you're being vaccinated for.*

Sandra, a scientist, outlined the importance of research and testing before a vaccine was released to the public:

> *…there's obviously a lot of research and scientific evidence that goes behind the majority of vaccinations that are out there. There's a lot of testing that goes into them…there's always a small risk with the introduction of anything into your body, so you're bound to have some small side-effects.*

Sam, a science specialist and also a supporter of national vaccination programs, had an interesting take on what he called vaccination for "lifestyle diseases":

> *So, like hepatitis C, I think it is, which is predominantly associated with drug use and the vaccination for the herpes strain that's associated with cervical cancer. I don't know whether, in the overall picture of public health that encourages people to take risks they wouldn't otherwise take…imagine you had developed a vaccine against the health effects of alcohol so you could drink as much as you like and your brain is never damaged and your liver is never damaged, but there's still all the other social impacts of that, so would we think that was a good idea or not?*

Experience of observing another person suffering from a vaccine preventable disease was also identified as a strong motivator for vaccination as indicated by Tina's comment:

> *I was a nurse for a while and I saw the results of some children coming in with things like tetanus…horrible-horrible disease. You do not want to see anyone go through it. So I guess I have seen the other side of it where people do get those diseases. They have, you know, they do exist and you do not want to see anyone suffer from them.*

However, two individuals raised some significant concerns about mass vaccination programs. One concern was that vaccines are unnecessary and have a negative effect on the immune system particularly for "minor" diseases such as mumps and measles. The elimination or control of infectious diseases such as measles in most parts of the world may have led to some complacency and the belief that concerns about measles are over-rated and anachronistic, while autism, which has been previously linked to the MMR vaccine, is a life-long condition that

places huge strain on the child and their family (Nicholson & Leask 2012). Indeed, infectious diseases such as measles are sometimes seen as 'a benign rite of passage in a normal childhood' (Nicholson & Leask 2012; p. 3810). Similar views were expressed by Sophia:

> *Most of the vaccines to me are not necessary…there's two categories. You've got the ones of illnesses that, you know, are very serious, that can kill a child or a person, and you've got ones that are childhood illnesses, like measles, mumps. Those – the childhood illnesses, I feel like they're really important for children to have. It's part of building their immunity, it's part of their life experience…and you're actually denying the child a right to have those diseases.*

Another concern commonly expressed by parents is related to specific ingredients in vaccines such as mercury-based preservative thimerosal and its link to autism (Baker 2008), a view expressed by Sophia:

> *I don't think it's protecting the nation at all. If anything, it's creating a whole lot of other problems…it [vaccine] is also putting a whole lot of stuff in that you don't know…when children have a reaction...you know, it seems like autism is increased.*

Parents commonly express concern about immune overload, especially for immature immune systems (Brown, Kroll, Hudson, Ramsay, Green, Long, Vincent, Fraser & Sevdalis 2010; Kennedy, Basket & Sheedy 2011). Single vaccines are considered safer than combined vaccines such as the measles, mumps, and rubella vaccine (MMR), although this heightened concern could be linked to the recent controversy surrounding the MMR vaccine (Hilton, Petticrew & Hunt 2006). This concern about the detrimental long term impacts of vaccinations on individual immune systems and thus society as a whole was expressed by Peter, whose argument was somewhat Darwinian and involved 'letting nature take its course':

> *I am worried about the danger to the society…so, to me, we are weakening humanity by not allowing the natural process to take place whereby people build up resistance themselves. I'm not sure whether people have done enough research into what the long-term effects on the immune system would be on constantly stimulating it in this way. Whether perhaps there's only so many times in a lifetime that you can – your body will be successfully stimulated to make an immune response like this. And the other one is, of course, that these diseases are constantly mutating so we can't be sure that if any vaccine is going to keep working in the long term. So, there could be long term global consequences for this.*

Out of the 33 participants, 10 reported hearing stories of adverse reactions to vaccines, although only one of them had personally experienced a bad reaction. The stories mentioned friends, other family members such as children or cousins and neighbours. When asked if this would stop them getting vaccinated, most of the participants said they felt some level of concern, but not enough to refuse vaccination, most choosing to rely on the statistical evidence related to vaccine safety. For example, Libby said:

> *I trust the Australian medical system professionally, so the major concerns would be tested out … I'd say 90 percent with a little – the occasional niggle about what it is and how do we all agree on these things are needed.*

Similarly, Margaret, a scientist and mathematician, was aware of the potential side effects of vaccination but factored in probability when coming to a decision about vaccinating her own children:

> *I was worried at the time about reactions [to the vaccination], but I stopped and thought about that and thought I would much prefer them to not have to go through the disease and I did look at the numbers…the percentage that did have a serious reaction so I thought the probabilities were much better to not have a reaction.*

However, the media coverage of a specific vaccination programme can impact even trained scientists' perception of the safety of vaccines, especially when seen as affecting close family and friends. Sian, a scientist and an advocate of vaccination programs, described a newspaper story on adverse reactions of young females to the human papillomavirus (HPV).

> *It was on the newspaper…it's eye-opening, obviously, because it does scare you…it might have changed my view on this particular vaccine. But now I know the risk associated with it, I'll be a little bit more cautious. So, knowing that is definitely important and I think – I suspect if it happens to someone really close to me, then I guess I might feel a little bit more strongly about it, even though I have a scientific background – I often see things in a probability, so what's the chance of getting this and that, but I think, if it happens to someone close to you or a family member, you get that emotional factor [entering] into your judgement.*

Interestingly, one participant, Greg, a scientist, despite his son having quite a serious reaction to a childhood vaccination, still believed in mass vaccination for the greater good:

> *My son went through the entire vaccination process and he developed a significant reaction to one of these measles injections and he ended up catching the measles…whether or not it was something to do with the injection or not who knows, but he ended up in intensive care and spent quite some time there… I believed that a national program goes an awful long way to removing those illnesses from the general population.*

Greg's son was subsequently vaccinated for polio, whooping cough and tuberculosis.

Factors that influence decisions about vaccination uptake

A range of factors emerged that influenced participants' decisions about vaccination uptake. The two most frequently mentioned factors, which have also been cited in other literature on vaccine decision-making, particularly by parents (Hilton et al. 2006; Kennedy et al. 2011) were:

- Vaccinations provided preventive and protective measures
- Weighing the risk of side effects from vaccinations against getting the full-blown disease.

For example, Mia commented that *"...it's a bit like an insurance policy, I guess. I wouldn't have considered not having my children vaccinated".*

While Celia stated *"I'm aware that there are reasons to have concerns, but I think the overwhelming benefit of vaccination far outweighs the possibility of it causing problems".*

Other factors that emerged from the interviews, listed in decreasing order of frequency, included:

- The prevalence of the disease or the likelihood of catching it
- Whether the vaccine was really necessary (the flu vaccine was commonly used as an example here)
- Personal health reasons such as being asthmatic
- Moral obligation
- Based on professional medical advice

- Following government legislation
- Seriousness of the disease
- Previous experiences with vaccines
- Cost
- Effectiveness of vaccine
- Concerns about the level of research around some vaccines, particularly lesser known vaccines such as the yellow fever vaccine
- Personal experience of serious diseases

Many of these factors correspond with the 5As taxonomy for the determinants of vaccine uptake, as suggested by Thomson, Robinson and Vallée-Tourangeau (2016). These researchers undertook a literature review that identified five dimensions, access, affordability, awareness, acceptance and activation (5As) that captured all identified determinants of vaccine uptake (Thomson et al., 2016). However, for the cohort in our study, factors associated with access and affordability were infrequent because most of the participants were in well paid jobs, with easy access to healthcare systems. In fact, only one participant mentioned cost as an issue (during her student days). Furthermore, the participants were also well placed to improve their awareness of vaccine-related information because they knew where to and how to access reliable information. The factors related to acceptance, such as the vaccine itself, the disease that the vaccine was meant to provide protection from, individual characteristics of participants and social context, were more common in this study. For example, the severity of the disease that the vaccine claimed to provide protection from was an important factor in uptake as shown by Jack's comment below:

> *These are two different things, really. Yellow fever vaccination is a much – like you, because it's an entry requirement, you have to take it or you can't get into the country. And also, because of the seriousness of the illness, I'm more inclined to take that…hepatitis…I think I got another vaccination. Anyway. But to me, flu vaccination – I've never taken flu vaccination.*

Activation involved interventions that "nudged individuals towards vaccination uptake" such as workplace policies (Thomson et al. 2016; Blank, Schwenkglenks & Szucs 2012). Many of the participants in this study had free access to seasonal influenza vaccination provided by their employer. However, the necessity of this vaccine was questioned by some of the participants, for example, Tony said:

> *I'm perfectly healthy...because I think we have a built-in immune system in our body and I think that needs to be utilised once in a while…so I'm generally opposed to any of the vaccinations against flu…I just don't think it's necessary and there's a lot of over-medication of bodies and I'm really opposed to it.*

However, other participants such as Ian took advantage of this opportunity:

> *For flu vaccination, I typically get information through my employer, I suppose about what's available – what's happening. So, I've only recently got into the habit of getting flu vaccinations.*

The politics surrounding national vaccination programmes could also have an impact on an individual's decisions about vaccination uptake. For example, individuals may be influenced by the perception that doctors, government and pharmaceutical companies are in collusion and thus, may not be accepting of evidence from sources that the medical profession might regard as reliable (Nicholson & Leask 2012) as indicated by Andrew:

> *So, what you're getting these days is, of course, the pharmaceutical companies putting combinations of them [vaccines] together. So, they say you only need one injection for these … so that's another way for them to create a patent for them to make lots of money and you imagine, you know, two million kids a year in Australia being vaccinated at whatever cost it is? I mean, that's not huge bucks, but that's still – that's a nice steady income from the pharmaceutical companies. So, it's been well-known that the Coalition is in bed with the pharmaceutical companies.*

Interestingly, another aspect of politics around national vaccination programmes was raised by Gillian who believed that the recent move in Australia towards banning of unvaccinated children from childcare centres in some states could have serious implications for vaccination programs:

> *Well, for example there was an item just recently in the – I think it was on television – in the media about childcare centres that were going to ban children because they didn't have vaccinations. So – and that's quite topical because in the early childhood area and if you come from a right space perspective, all children have a right to have early childhood education programs, and then I don't like it being seen that it becomes a political football around vaccination or it – and that also has financial implications for families as well.*

Sources of information on vaccination

The participants used a wide range of sources when accessing information on vaccinations (Table 3). The most common sources of information cited by the participants included general practitioners or health care workers. Other quantitative studies that investigated parental vaccine attitudes have reported similar findings in that parents list health care providers as their preferred and trusted source of vaccine information (Kennedy et al. 2011; Freed, Clark, Butchart, Singer & Davis 2011). Furthermore, a qualitative study on parents' knowledge and attitudes about the human papillomavirus (HPV) vaccine indicated that female caregivers often held primary responsibility for health decisions and that parents preferred receiving vaccination information from their daughter's health care provider (Allen, de Jesus, Mars, Tom, Cloutier & Shelton 2011).

Table 3: Sources of information on vaccinations used by participants

Source of Information	**Number of Respondents***	
	Non-Science	**Science**
Experts in the field	0	2
Family/friends/acquaintances	3	2
General Practitioners/Health Care Workers	13	13
Internet/Social Media	11	10
Newspapers/Medical Pamphlets/Magazines	6	6
Personal Experience	1	0
School/University	3	7
Scientific Research	1	1
TV/Films/Radio	6	8

*Some participants used more than one source of information

Our study showed that of the participants who stated general practitioners or health care workers as their sources of information, 18 were females while 8 were males. This is perhaps a reflection on the role of females as primary caregivers who make the decisions regarding vaccination for their children as reflected in this comment from Mark:

> *No, I don't know that I would [look for information on vaccinations]. I can't speak for my wife, who would have been the one who was the main person behind it…it's more out of interest and so it's kind of like a Reader's Digest level of it and once I'm satisfied that I kind of get the idea of what's happening – I didn't sort of strenuously investigate it.*

The internet and social media were reported as the next most common source of information on vaccinations. The most common websites that were used by participants included government sites such as the Department of Foreign Affairs and Trade (DFAT) in the case of individuals traveling overseas and New South Wales Health as well as medical websites. Interestingly, only two participants, both female, mentioned social media and only in a negative sense that this would not be a source of information that they would rely on. For example, Rita commented:

> *Obviously, I was looking at the side-effects…there's so much, particularly social media now on parenting groups that are against vaccinations, and so there's a lot of information that I'm aware of that's out there that's against vaccinations, but I have to tell you that I avoid going down that path because I don't want to scare myself out of it…I'm aware of the risks, but I think the risks are much greater if I don't get my child vaccinated.*

Television and radio also emerged as sources of information. Most common ones mentioned by the participants included Australian Broadcasting Corporation (ABC), Special Broadcasting Service (SBS) and BBC news and radio channels. Some of the participants utilized more than one source of information. For example, Tom stated that *"I think this has changed over time. Initially, I would use my doctor to get this information, but now that this information is readily available online, I usually will check online"*.

Steve who came from a non-science background also drew on television as well as print media:

> *I was convinced by the epidemiological evidence that, without mass vaccination then you can get returns of mass illness. I followed it on TV and the papers as that debate sort of rolled on.*

Only one participant, Sean with a science background, mentioned experts in the field as their source of information, being careful to make a distinction between a generalist such as a general practitioner and an expert:

> *…it wouldn't be a doctor, not a medical doctor…they are very generalist people who have been trained across a lot of things, but they don't know anything in great depth about any one thing. So, I would go to a specialist or a university researcher or somebody who specialised in that area.*

The overriding impression from this cohort was that they were very active in finding out about a vaccine and that they were quite discerning in the sources they utilized to gather this information. For example, sources that have been traditionally seen as reliable such as General Practitioners (GPs) and health care workers or dedicated government websites that provide up to date travel vaccination information were most commonly mentioned.

Conclusions

Gregson (2018) argues that science education should develop skills of critical thinking so that individuals could make informed decisions in the face of sometimes conflicting information when considering SSIs. In the area of vaccination there is certainly considerable conflicting information available, both online and in the media. Furthermore, there are quite vociferous anti-vaccination groups in countries such as Australia and the USA, presenting arguments that are counter to the views of the scientific community. Such groups use emotive cases of individuals who have allegedly suffered serious side effects or ongoing aliments as a consequence of vaccination, promote articles questioning the concept of herd immunity and continue to claim a link between the vaccination and the development of autism in children (Australian Vaccination-skeptics Network 2018). The arguments are presented persuasively and individuals reading them without some level of scientific literacy and in particular some knowledge of the scientific research supporting mass vaccination, could be convinced that vaccination is generally quite high risk. This may be having an impact as in 2013, government released figures that showed levels of childhood vaccination have fallen to dangerously low levels in some areas of Australia (Dunlop 2013).

This relatively small qualitative study was undertaken with well-educated individuals, and any findings should be treated with caution. However, it indicated that within this group, the type of educational background (science and non-science) did not, in general, appear to be a determinant of support for mass vaccination programs as both groups were largely supportive of such programs to protect populations against serious diseases. Furthermore, despite being aware of or having experienced some side effects associated with vaccination, there was generally high confidence in vaccine safety, and although some of the participants reported reading articles portraying vaccination in a negative light, they appeared to trust the overwhelming view of the scientific community that vaccination is beneficial for individuals and the broader society. This may indicate that these participants were engaging critically with the media, in the manner proposed by Gregson (2018), thus indicating significant levels of what Priest (2014) would term critical scientific literacy. Also, the tertiary education experienced by science and non-science graduates alike in this study suggests to some extent a shared minimum level of analytic thinking, and analytic thinking has been shown to reduce belief in conspiracy theories (Swami, Voracek, Stieger, Tran, & Furnham 2014) such as those linked to the thoroughly discredited association between autism and vaccinations. However, even within this cohort, two of the 33 participants did present arguments against mass vaccination and for one participant it impacted on her decisions around the vaccination of her children.

Implications

Science education plays an important role in adequately preparing people with the appropriate information to make well-informed decisions about important SSIs such as vaccination, although this may not have been critical with this tertiary educated cohort, some of whom claimed to have done quite detailed research into vaccinations. However, others within the population may not engage with the subject in this way and be more swayed by hearsay and emotive media reporting. Within any population there will be individuals who read articles in an uncritical way. The use of an expert as an authority figure in reporting, can be highly persuasive. Moreover, pitching one ‘expert’ against another when reporting on issues such as vaccination, or as currently happens more frequently with climate change, gives the impression that the scientific community is divided (Speers and Lewis 2004). If individuals draw this

erroneous conclusion, the problem may well be compounded if it is spread widely on social media. The relatively strong impact of "social proof" (what our social networks think) on our attitudes and actions over "evidential proof" in relation to SSIs such as vaccination has been established (e.g., Contractor & DeChurch 2014). Yet others may engage in detailed research, but view and filter their findings through different lenses unrelated to science, such as ideological commitments to freedom from coercion, or particular philosophies or belief systems. Finally, studies (e.g. Jolley & Douglas 2014) have reported that belief in anti-vaccination conspiracy theories correlates with lower intentions to vaccinate.

These situations and the limited persuasive power of scientific evidence that they demonstrate continue to be an issue for policy makers and curriculum developers to consider, as vaccination is one SSI that affects almost all individuals and the choices individuals make, not only affect them, but potentially the wider society. These situations underscore arguments for not only educating individuals in science, but in how better to analyse and interpret science as it is presented in the media. The Science as Human Endeavour strand in the Australian Curriculum is certainly an attempt to address this kind of issue, although an effective translation of this change into pedagogical practice may be problematic (Saunders & Rennie 2013; Hardy, Chartres & Paige 2013).

It has been argued by Priest (2014) that we need to move beyond scientific literacy, and to think in terms of critical scientific literacy, for citizens to learn how science works and be able to reflexively think about scientific practices. Similarly, McClune (2017) argues that to be relevant and useful, science education needs to engender a level of critical literacy that keeps pace with science in the news, and particularly in social media where people are increasingly obtaining their news sources. It has long been advocated that scientific literacy can be facilitated in schools by engaging students in argumentation to justify and evaluate knowledge claims using frameworks such as the Claim-Evidence-Reasoning (CER) framework (e.g. Skamp 2018). Teaching critical scientific literacy can beneficially include training in the ability to read, understand, analyse and critique media reports with a science component (McClune 2017). Although others have called for this previously (e.g. Millar 2006), there remains a need for longitudinal studies in which students critically analyze science-based media items (McClune 2017). This may work well in the case of an SSI like vaccination, if students were presented with material from an anti-vaccination website and asked to critically analyze it with reference to accessible articles from the scientific community that outlined the historical and present benefits of mass vaccination.

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Note: There are no competing interests in this article

Appendix

INTERVIEW QUESTIONS

1. What is your understanding of vaccination? How do you know that?
2. Where do you get your information on vaccinations?
3. What ideas do you consider when thinking about vaccination uptake?
4. Can you explain how vaccinations are supposed to protect us?
5. Do you have any fears or concerns about vaccination?
6. Have you or anyone you know had a bad reaction to a vaccine?
7. Do you support national vaccination programs? Why or why not?
8. Using the following Likert scale (strongly disagree, disagree, unsure, agree and strongly agree) please indicate your opinion on the following statements:

- Vaccinations are unsafe
- Vaccinations cause side effects
- Vaccinations weaken the immune system
- Vaccines are not compatible with my religious and/or personal beliefs
- Vaccines are associated with particular illnesses such as autism
- The individual risks associated with vaccinations are outweighed by the benefits of a national vaccination program for the nation as a whole.