Vaccines: Are they Worth a Shot?

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Springer

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The translation of this book has been funded by SEPS SEGRETARIATO EUROPEO PER LE PUBBLICAZIONI SCIENTIFICHE, Via Val d'Aposa 7, 40123 Bologna, Italy, e-mail: seps@seps.it, www.seps.it

ISBN 978-3-319-68105-4 ISBN 978-3-319-68106-1 (eBook)
https://doi.org/10.1007/978-3-319-68106-1

Library of Congress Control Number: 2018942232

Cover illustration by Anne-Lise Boutin

Printed on acid-free paper

This Copernicus imprint is published by the registered company Springer International Publishing AG part of Springer Nature.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To my mother, who gave me my first immunity

The only true voyage of discovery, the only fountain of Eternal Youth,
would be not to visit strange lands,
but to possess other eyes.
Marcel Proust, *The Captive*

Liberty cannot be preserved without general knowledge among the people.
John Adams, *Dissertation on the Canon and Feudal Law*

Truth, the harsh truth.
Stendhal, *The red and the black*

Foreword

Vaccines have led us out of the Age of Darkness into the Age of Enlightenment. Because of vaccines, children no longer have to routinely suffer diseases like meningitis, hepatitis, pneumonia, and sepsis and a variety of other potentially fatal infections. Unfortunately, vaccines have now become a victim of their own success. Young parents today don't see many of these diseases; they didn't grow up with them. For these parents, the promise of vaccines is not nearly as compelling as it was decades ago.

Further, we have moved from an era where scientific illiteracy has been replaced by scientific denialism. People simply declare their own "truths" no matter how much information is available to refute them. Perhaps worst of all, many people have become afraid of scientific advances, worried that we have stepped beyond our bounds and that we are doing more harm than good. "We have guided missiles but misguided men," said Martin Luther King, Jr.

Into the fray steps Andrea Grignolio. Unlike previous books on the subject, *Vaccines: Are they Worth a Shot?* takes a broad overview of the problem. Not only does Grignolio address the history of the anti-vaccine movement starting with humankind's first vaccine, smallpox; he also examines the political, evolutionary, sociological, and media influences that impact how we perceive vaccines. Perhaps most interesting, Grignolio examines changes in the doctor–patient relationship, why as a society we have moved from skepticism to cynicism, how we perceive risk, and how we reason.

Vaccines: Are they Worth a Shot? also offers a way out: a practical guide for how to separate good information from bad information. As more and more parents choose not to vaccinate their children and as the number of preventable

outbreaks of serious infectious diseases increases, Grignolio's book is a timely and important addition to a problem that can no longer be ignored.

Much is at stake.

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Who Is Afraid of Vaccines?

The 1980s: When the Decline Started

The history of anti-vaccination movements is long and instructive. We can trace its beginnings back to late eighteenth century England and the practice of vaccinating against smallpox. From a historical point of view, we cannot say that opposition to vaccinations is anything new; what is new today is the increasingly large number of people involved and their social status. In addition, for the first time, we are seeing a decline in the vaccinal coverage of the population after two centuries of slow but inevitable advances: we are consequently seeing something very different from the opposition to vaccination in the past by some marginal groups.

We are losing what is known as *herd immunity* (also called *community, group or flock immunity*) thanks to which infectious diseases do not spread in a population if a certain percentage of individuals (which varies from 85% to 95%, depending on the contagiousness of the disease) has been vaccinated; this is a central concept which we will come back to several times. This drop in the threshold of vaccination coverage is not easy to explain, but history, as always, can help us understand.

In the past, vaccination was something unknown to which the population, with a very low rate of literacy, was subjected. They accepted a procedure which to their eyes could not fail to appear counter-productive: inoculating an infectious agent into people to make them immune towards probable future epidemics. Yet, in the nineteenth century, this practice successfully spread from London, with the preventive inoculation of attenuated smallpox, to

A. Grignolio, *Vaccines: Are they Worth a Shot?*, https://doi.org/10.1007/978-3-319-68106-1_1

Europe and the United States. This was thanks to (as we will see in Chap. 5) the active participation of wide sectors of the cultivated population and above all, of the aristocracy, obviously together with other factors such as literacy and the promotion of public hygiene.

After almost two centuries of fighting smallpox, the first vaccinations against rabies, anthrax, diphtheria and cholera arrived at the end of the nineteenth century, but there was a real explosion in vaccinations in the twentieth century, which we can define the century of vaccinations. Diseases with a high mortality rate (with names that are still terrifying today: plague, tuberculosis, typhus, yellow fever and smallpox), which had claimed the lives of millions of people, started to recede for the first time, thanks to the vaccinal prophylaxis. Together with smallpox, the eradication of poliomyelitis—after peak diffusion had been reached in the mid-1950s in the United States and in Europe—was an unprecedented success: in December 1979, the World Health Organization (from now on WHO) announced the global disappearance of smallpox, while the last cases were registered in 1979 and 1982, respectively, in the USA and in Italy.

The 1970s were probably the highest point of the success and involvement of the population, as it was also the decade in which the MPR vaccine (also known as MMR vaccine) was introduced for measles, parotitis (commonly known as *mumps*) and rubella (or German measles). These are diseases which usually affect children by 5 years of age and which, contrary to popular belief, have a mortality rate that is anything but negligible.

In the early 1980s, nobody could have imagined that from then onwards there would have been a growing lack of confidence in vaccinations, with mistrust spreading above all in the most educated and affluent sectors of the population. Today, several Western countries have whole regions under the threshold of safety for diseases such as measles, diphtheria, German measles, mumps, whooping cough and some forms of meningitis. Why, then, from the 1980s onwards, after two centuries of success after terrible infectious diseases, have parents shown an irrational attitude towards vaccinations, refusing this treatment for their children? Besides, these parents belong to advanced democracies, have a good level of education and a good or high social and economic status—all characteristics which usually are correlated with longevity and an efficient relationship with the best medical and health behaviour.

The reasons for this inversion of trend will be discussed in detail in this book, but here we can mention the main ones, focusing our attention on the parents of children of vaccination age (3 months–15 years). There are fundamentally three reasons: neurocognitive, social and evolutionary. Let's start with the first ones.

A Neurocognitive Explanation: Education and Risk

Vaccinations are a prophylaxis (from the ancient Greek *prophylaxis*, meaning "I prevent", "I preserve", from which *prophylactic*, meaning the male prophylactic against sexually transmittable diseases, also comes), a preventive treatment made up of rules and measures which have to be adopted collectively or by individuals, to offer protection from the spread of specific diseases, both infectious and not. Unlike other prophylactic practices, which come within the rules of preventive medicine, vaccination is fairly counter-intuitive and, therefore, particularly difficult to understand. Let's take the example of two well-known cases such as oral hygiene or asbestos. Cleaning your teeth every day with a toothbrush and fluoride toothpaste is part of the dental prophylaxis to keep bacterial plaque and tartar under control and to remove residues of food and sugar. Oral hygiene is something that can be perceived, as well as an aesthetic and even cultural question. In addition, anyone who neglects their oral hygiene is headed towards a progressive inflammation of the gums and, in the end, painful toothache, a gradual and tangible pathological process. Less evident, but again easily understandable, are the reasons for the prophylaxis of workplaces full of dust or particles that are dangerous for human health. These are cases in which high rates of diseases from intoxication are known, especially in the community of workers of certain chemical companies. Whereas in the case of oral hygiene, the agent to be protected from is invisible to the naked eye and the onset of pathologies is gradual; the prophylaxis for asbestos consists of perceivable procedures, such as decontaminating workplaces, limiting the production and spread of the harmful dusts and, lastly, reducing human exposure through masks, overalls and breathing apparatus etc. The case of vaccinations, i.e. the prophylaxis against infectious diseases through inoculation of the pathogenic agent for preventive purposes (we will see that there are also therapeutic vaccines), is much more complicated to understand and accept. We have to reflect on the fact that paediatric vaccinations are a pharmacological treatment which is applied not only to adults in unhealthy contexts but also to children who live in (apparently) safe environments: this is a substantial difference. To understand it, it is sufficient to examine the cases of children affected by severe pathologies caused by cancer, by autoimmune diseases or by major physical traumas: their parents show almost no resistance to therapeutic or analgesic drugs, which are by no means free of possible side effects. When it is a question of dealing with a disease or physical pain, deciding on the risks/benefits of a drug is made on fairly rational and pragmatic bases. Unlike other drugs or medication given in illness, the vaccine has to be

administered to a child in a good state of health. Those who do not know that the production processes are controlled, safe and certified by continuous studies and international bodies, also see it as a pharmacological treatment with a potential risk, coming from the inoculation of a pathogenic agent with attenuated virulence (as we will see better in Chap. 5). "Live attenuated", however, is only one of the possible ways of producing vaccines: there are also "inactivated" vaccines (in which the infectious agent has been killed), the ones against pathogenic subunits and toxins, and, lastly, those constructed with molecular strategies from genetic material or protein portions of the pathogenic agent. It is not always easy for a parent to accept that a pathogenic agent, or a derivative of it, is injected into their child's blood purely for prevention. This first reason for refusal by parents is not to be attributed only to the generations that lived in the 1980s but we will see how in actual fact, from that period onwards, TV and the press started to circulate erroneous beliefs and stories breeding anxiety about vaccines, increasing in parents the perception of the risks of vaccination rather than of the diseases from which they offer protection.

The very concept of prevention is actually a source of great confusion and refers to a second problem in the neurocognitive context: today, subjects are vaccinated in the presence of a risk that cannot be seen, but only imagined. Luckily, the infectious diseases have virtually disappeared, but the microbes that cause them are still here. From the 1980s, the disappearance from the streets in our cities of semi-paralysed invalids with poliomyelitis, people with tuberculosis exhausted by consumption or people disfigured by smallpox also meant the loss of effective social alarms and of useful evidence of the perception of the collective risk. In this case too, not all parents are willing to rationally face a risk which is real but not visible. It is not infrequent to hear that in Western countries, "severe" infectious diseases have now disappeared or that "minor" diseases such as measles, diphtheria, chicken pox, whooping cough and tetanus can be naturally contracted by unvaccinated children without risks. In actual fact, both the pathogenicity (the capacity of a microorganism to inflict damage on its host and give disease) and the contagiousness (the capacity of a microorganism to naturally transmit from an infected animal, even though a healthy carrier, to a receptive one) of infectious diseases has been reduced precisely thanks to the spread of vaccines (again see Chap. 5). For this reason, compared to 30 years ago, infectious paediatric diseases today are less aggressive and common; proof of this is that the recent drop in vaccinal coverage has inverted this trend, making very virulent strains re-emerge which have caused several deaths. Only to mention some data from recent months and relative to geographical areas close to us, in 2015, several unvaccinated

children lost their lives, in particular: in March a 4-year-old girl at the Bambin Gesù Hospital in Rome died of measles; in October a baby of only 1 month—the victim of the lack of herd immunity as it was without vaccinal cover being of pre-vaccinal age—in Bologna, from whooping cough; in June a 6-year-old girl in Spain died of diphtheria (making an alarming return 30 years after it had disappeared in 1986!); and, lastly, an outbreak of meningitis in Tuscany led to the deaths of seven people. This epidemic in only the first 3 months of 2016 had already killed four people, again in Tuscany, and between the end of 2015 and the early months of 2016, a health emergency against measles had already been recorded in Milan: 50 cases and several admissions to hospital. Lastly, in March 2016, a Dutch girl aged three, who had not been vaccinated, died of diphtheria at the hospital of Antwerp, without the doctors being able to find the drugs necessary (diphtheria antitoxin) against this infectious disease, erroneously believed to have been eradicated.

There is also a third, fairly complicated reasoning which escapes the parents who oppose vaccinations: it is the idea that their child can avoid being vaccinated in consideration of the fact that all the others have already been made immune by the vaccinations. This reasoning is wrong and morally questionable, because it ignores a central element. Vaccinations work as a collective phenomenon, not an individual one. When viruses and bacteria enter an individual, they multiply very quickly, and in doing so change significantly, modifying their conformation and ending up by differentiating themselves from the initial standard strains on which the vaccines have been formulated. A little like in the game of Chinese whispers, when a sentence sent to the first member of a group reaches the last one saying completely different things, from one infection to the next, the virus modifies its characteristics becoming difficult to identify. This means that if in a class there are children who have not been vaccinated, not only, as is obvious, are they themselves the most in danger if an infectious agent is in circulation but less intuitively, they also represent the host organisms (called *reservoir*) in which the pathogens develop and are diversified, thus gaining the ability to infect their vaccinated classmates, whose immune system does not recognize the changed forms: this is the mechanism on which herd immunity is based. If 95% of the pupils in a class are vaccinated (let's say 19 out of 20 children), then it is improbable that the virus can spread, also because if an unvaccinated child were to be infected, the number of transformations (mutations) of the incubated pathogen would not be such as to dramatically change its characteristics: it will try to infect the other classmates, but with all probability the contagion will stop because the immune system of the vaccinated children will identify it and the antibodies will eliminate them, recognizing them as a "brother" of the standard pathogen

inoculated with the vaccine. If, however, there are two children (90% coverage) in the class without vaccinal cover, then it is likely that the pathogenic agent can infect the second individual as well and in the two passages it would succeed in being sufficiently transformed so not to be recognized by the antibodies of the vaccinated classmates, who would therefore be infected. This is why it is nonsense not to vaccinate one's children thinking that they can benefit from the coverage of the others, and the threshold of 95% is too high for someone to arbitrarily allow themselves the luxury of not respecting this rule of common protection. In addition, there is an ethical consideration that recalls some phenomena of biological parasitism: it is incorrect to enjoy the social benefits of immunization without taking on the risks as well, even though very rare, of the allergic reactions sometimes caused by vaccinations. Although the percentage of adverse effects from vaccinations is the lowest of all the drugs available today—about one case out of a million (as I will show in Chap. 5)—this risk has to be shared by the whole population. Only the individuals of a pre-vaccinal age, those who have immune deficiencies, such as for example cancer patients, those who are affected by autoimmune diseases or patients who have undergone transplants are morally exempt and they are exactly the people who are in extreme need of the coverage of the collective herd in order to survive.

These three reasons can all be traced back to a mistaken perception of the risks/benefits ratio, which will be discussed in greater depth below (in the paragraph on late fertility in this chapter and in Chap. 6). In actual fact, the ability to evaluate the balance between risks and benefits is central not only in vaccinations but in the whole of medicine, and it is also particularly significant in the world of finance, in many political decisions and in many other areas of today's knowledge society. Today, there is an over-production of data, personal computers are commonplace and access to the Internet is easy. This means that complex data which were once restricted to experts—such as scientific articles or reports on drug safety or the adverse effects of drugs and vaccinations in the phase of post-marketing control—are now within reach of people who do not have the knowledge required to contextualize and interpret it. They then repost this information in an alarming way on the Internet, where it can be uncritically reposted. We are not talking here about the creation of pseudo-scientific hoaxes, a very central theme in vaccines, to which a whole chapter (Chap. 3) will be devoted, but simply about the fact that, due to an apparent paradox, having more information does not always lead to making the correct decisions, especially if these entail a risk (Covello et al. 1986; Covello and Sandman 2001; Morini 2014; Gigerenzer 2015). The reasons for this behaviour have become clear in very recent years thanks to a

series of interesting publications on neuroscience, behavioural economy and cognitive psychology and which explain how the human mind has evolved in a past biological context which today makes it unsuitable to assess long-term predictions, calculate uncertainties and above all, risks. This "bounded rationality" (a topic which led to the Israeli psychologist Daniel Kahneman being awarded a Nobel Prize in 2002) concerns all the sectors of the population, as it is an evolutionary trait of the human species (Kahneman 2012). If, however, we ask which sectors of the population are most subject to information overload and the assessment of risk in a medical context, we can understand immediately that it is the most affluent and educated ones. This is why the social reasons and lastly the evolutionary ones, of the refusal of vaccination, have to be analysed.

Let's take one small step backwards. In the past few decades, there has been great insistence on the fact that it was the so-called high sector of the population that had the best understanding of hygiene and health practices and the most efficient access to medical and pharmacological therapies and therefore was also the one with the greatest longevity. Therefore, in the population, a good education and economic possibilities correspond on average to a better state of health. All this is statistically valid, although unfair, as shown by the very name of the disciplinary context that deals with this: *health inequalities* (Crimmins et al. 2011; Grignolio and Franceschi 2012; Neumayer and Plumper 2015).[1] How can it be explained, then, that in the same segment of the population this ratio can be inverted, from positive to negative, precisely when we are talking about vaccines? To simplify, we could say that the ratio is inverted only when a potential risk is involved together with multiple contradictory pieces of information. This is effectively the case of vaccines (Casiday 2007) and a few other topics linked to technological and biomedical innovations, such as some advanced therapeutic treatments (Cassell et al. 2006), global warming (Kahan et al. 2012), nanotechnologies (Kahan et al. 2009) and genetically modified organisms (Finucane 2002; Blancke et al. 2015).

Is it more sensible to offer children immunity from potentially lethal disease or leave them uncovered out of fear of a severe allergic reaction that appears following one vaccination out of a million? Why are those who fear these very rare adverse events linked to vaccinations willing, to relieve negligible malaises, to ignore the risks (hundreds of times greater) of severe side effects caused by common anti-inflammatories and aspirin? Why don't the more radical parents who refuse vaccinations out of fear of autism change

[1] See the website and manual of the WHO (http://tinyurl.com/jysh983I) and the one promoted by the European Community through EuroHealthNet (http://eurohealthnet.eu/).

their minds even if they are shown evidence and clear data that show the extraneousness of that disease to vaccination? All this happens because during the decision-making processes in which risk, uncertainty, probability and long-term forecasts appear, the brain of *Homo sapiens* does not make rational decisions, having had an evolutionary story that has not selected it to face up to these topics, which have emerged in too recent a past. Today we know, for example, that our brain tends to remember and give greater importance to the information that suggests a high risk, even if it is statistically insignificant, whilst it tends to underestimate the benefits or low-risk information, even though offered by institutional bodies (Viscusi 1997; Kahan 2014). This is exactly what happens in the brain of a parent when they come face to face with the decision-making processes that concern vaccinations for their children. This also explains why the so-called high sector of the population is particularly critical or doubtful with regard to vaccines: it is the most informed part of the population and is, therefore, exposed to information on the calculation of risks and benefits (Ogilvie et al. 2010; Anderberg et al. 2011; Brown et al. 2012). These parents have fairly elaborate cultural instruments, are mainly university graduates who, before vaccinating their children, decide to read up on the subject, often on the Internet and, coming up against "contradictory opinions" on vaccinations, end up by hesitating or even rejecting them.

The data of some Western countries available on these parents are fairly coherent, let's have a look at them.

43.55% of US citizens use the Internet to look for health information (Amante et al. 2015). On vaccines, in particular, a study of 2015 shows that it is "young, more educated parents and who oppose the requests of vaccinations for school admission who, with respect to pro-vaccination parents, use the Internet more as a source of information on vaccinations"; they are also the parents who have a low perception of the safety and efficacy of vaccines and, naturally, have the greatest rate of vaccinal exemption for non-medical reasons, or they use personal/philosophical or religious reasons. These parents who obtain "vaccinal information on the Internet are young, have a high educational qualification and a high family income" and coincide with that part of the population who "has not subjected their children to any of the routine school vaccinations" (Jones et al. 2012; Smith et al. 2004). As in other countries, we will see shortly that the vast majority of parents, still in the USA, deem that vaccinations are safe and 83% think even what on the Internet is accused of causing autism, i.e. the MMR vaccine, is safe, even though there is a consistent and growing 9% of parents who deem the vaccines unsafe, with an additional 7% saying they don't know or are undecided. A comparative

analysis between 2006 and 2013 reveals that in this period of time, the US paediatricians who reported documentation of the refusal of vaccinations by parents went from 74.5% to 87.0% and as a consequence their termination of the care relationship with the anti-vaccination families went from 6.1% to 11.7% (Hough-Telford et al. 2016; O'Leary et al. 2015), 68% (in 2009 69%) deem that the vaccines ought to be required for all children (the Hispanic minority is more favourable compared to non-Hispanic whites) while 30% (which becomes 41% of young parents between 18 and 29 years of age) deem that it has to remain a free choice of the family. With respect to the parents' decision on vaccinations, while in 2009 there was no difference regarding the political affiliation, in the 2015 surveys, Republicans were more in favour (34%) than Democrats (22%) (Anderson 2015) who appeared less inclined to allow exemption.

One study reveals that in Canada, where 57% of the interviewees said they went online (Google, social media, websites, etc.) for health information, in the case of an infectious onset of diseases preventable by vaccination, 335 would look for information on the Internet and 145 on the social media, and only 5% would use scientific sources (journals). The information obtained on the Internet influences the users in a contradictory way because although the majority (92%) believes that vaccines are safe and effective and only 6% decide not to vaccinate their children, no less than 28% of the interviewees believe that vaccines are related to autism, 27% that they can cause serious illnesses and 33% that compulsory vaccination is orchestrated by the pharmaceutical industries: these are typical arguments that come from the "rhetorical artillery of the anti-vaccine movements", increasing the share of parents hesitating over-vaccinations up to 35% (Greenberg et al. 2017).

In Australia, the Internet is the third source of health information, followed by 27% of citizens, preceded by the health authorities and institutions (28%) and the general physician (83%), who, although resisting as the most influential figure (8.37 out of 10) in the health context, is closely followed by the growing influence of the specialist (7.89 out of 10) and especially by those who practise "alternative treatments" (7.81 out of 10). The enquiry sample confirms that the Internet is followed as a source of health information far more (52%) by the groups that do not trust the classic health services compared (24%) to those on the other hand that do trust them, and while only 17% of the pro-vaccine people went on the Internet to look for the relative information, 50% of the anti-vaccine people used the web for information. The population that uses the web most for information tends to be young and also often trusts sectarian information, i.e. from family and friends. Even though 92% declare that they agree in full with vaccinating their children,