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IP Australia

Patent Analytics Hub

A Dose of Innovation: Patent Analytics of Virus Vaccines

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FOREWORD

Griffith University

Viruses from families such as the Coronaviridae, Togaviridae and Flaviridae have a positive-sense single stranded RNA ((+)ssRNA) genome. The global spread of (+)ssRNA viruses has resulted in numerous large scale epidemics. Within the last decade, outbreaks of poliovirus, Zika virus and coronavirus have all resulted in the World Health Organisation declaring a public health emergency of international concern.

The Emerging Viruses, Inflammation and Therapeutics group at Menzies Health Institute Queensland, Griffith University, is helping find new ways to treat debilitating diseases caused by (+)ssRNA viruses such as chikungunya, Zika and dengue viruses. In collaboration with The Institute for Glycomics, Griffith University, and with funding from the National Health and Medical Research Council and National Foundation for Medical Research and Innovation, our team are leading in-depth investigations into viral diseases pathogenesis, treatment and prevention. This research has generated new knowledge and intellectual property for vaccine design and delivery strategies.

Partnering with IP Australia has allowed us to map the intellectual property landscape of (+)ssRNA virus vaccine technologies, with a particular focus on chikungunya virus vaccines. This report will provide us with insight into the intensity of discovery and innovation in this area. Our valuable collaboration with IP Australia and the report will support our future research and commercialisation activities in relation to vaccination against (+)ssRNA viruses of major human health concern.

Doctor Adam Taylor
Early Career Research Leader
The Emerging Viruses, Inflammation and Therapeutics Group,
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Griffith University

National Foundation for Medical Research and Innovation

The National Foundation for Medical Research and Innovation (NFMRI) is grateful to IP Australia who continues to assist medical research projects we support.

The information provided in these reports provides a valuable resource for researchers and their institutions to understand the global research landscape identifying, trends, technologies, potential collaborators, partners and competitors.

Information in this report highlights the rapid growth in patents and research efforts since 2014 and correlates changes with infectious disease outbreaks in recent years. Identifying leading countries, companies, institutions, vaccine targets and patent families will greatly assist in the next steps towards translation

It takes more than research to translate discoveries into products and services that create a positive impact to communities in need. Patent analytics provides an effective and efficient resource to help identify opportunities along the innovation and translation pathway.

Dr Noel Chambers
Chief Executive Officer
National Foundation for Medical Research and Innovation

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SUMMARY

This patent analytics report investigates vaccine strategies used to prevent and control infectious disease outbreaks, with a focus on viruses containing a positive-sense single-stranded RNA (+)ssRNA genome.

(+)ssRNA viruses are very common and cause serious disease such as severe acute respiratory syndrome (SARS) (caused by coronavirus), Zika, foot-and-mouth disease and hepatitis, as well as the common cold. This report focuses on the (+)ssRNA viruses as vaccine technologies may be transferable between viruses with similar genomic structure.

This report was prepared in partnership with the National Foundation for Medical Research and Innovation (NFMRI) and includes a section on togavirus vaccines including vaccines for Chikungunya virus (CHIKV), which is of specific interest to the NFMRI.

2076 patent families have been **filed in vaccine technologies** for (+)ssRNA viruses **since 2000**

Patent family **filings** have **increased three-fold** from 2014–16

83 per cent of patent families are in an **active** state

The **United States Department of Health and Human Services** is the top global innovator, with **101 patent families**

The United States is the largest **filing destination** in the world, while **Australia** is **fourth**

Australian applicants filed 22 patent families; the **Burnet Institute** was the **top applicant** with **5 patent families**

131 patent families were filed **for vaccines** against togaviruses; **49** were specific **for CHIKV**

Inactivation/attenuation were the most commonly used **methods** in **togavirus vaccines**

INTRODUCTION

The prevention of wide scale infectious disease outbreaks, facilitated by rapid global movement, is one of the greatest human and animal health challenges of all time. As well as surveillance, identification and containment of new pathogens, developments in vaccine technologies are essential to quickly create and deploy new vaccines in response to emerging infection threats.

Viruses with a positive-sense single-stranded RNA (+)ssRNA genome[1] are both very common and cause serious diseases. In this report, we study patents on (+)ssRNA virus vaccine development, in particular for families of viruses that infect vertebrates: coronavirus, togavirus, flavirirus, hepevirus, picornavirus, calcivirus, arterivirus and asteriovirus.[2] Members of these families include the viruses that cause COVID-19, SARS, dengue fever, Zika, yellow fever, West Nile fever, foot-and-mouth disease, hepatitis, polio and measles, as well as the less harmful common cold. Their biological diversity and rapid adaptive rates present ongoing difficulties for disease control and have stimulated continuous development in prevention and treatment strategies.

We concentrate on this group of viruses to identify control strategies that might be transferable due to genomic structural similarity. This report also includes a section focused on togavirus vaccines, with an emphasis on CHIKV, which is of specific interest to the NFMRI.

Why patent data?

Patents can be used as indicators of innovative activity. By extraction and analysis of data associated with patent documents, we can measure aspects of inventive activity such as scope, intensity, collaboration and impact. These metrics can be developed across technology sectors and by measures including individuals (inventors), institutions (applicants) and regions.

Patents are granted for devices, substances, methods or processes that are new, inventive and useful (Appendix A: Definitions), giving exclusive commercial rights in exchange for full public disclosure of the invention. This means that patents are a source of data on innovation trends in science and technology.

The authors and purpose of this report

IP Australia is dedicated to building prosperity for Australia and ensuring that Australians benefit from great ideas. Using patent analytics to provide evidence of innovation trends, we leverage our unique access to IP data, knowledge and expertise to deliver value to the broader economy.

This report was prepared in partnership with the NFMRI as part of IP Australia's commitment to support Australian research and innovation. The NFMRI makes a social investment in biomedical research by partnering with researchers and donors to identify, evaluate and support innovative and high-quality research projects.

[1] International Committee on Taxonomy of Viruses, https://talk.ictvonline.org/taxonomy/w/ictv-taxonomy
[2] Data was excluded where vaccine preparations were not specific for viruses from any of these families

OVERVIEW OF PATENT DATA ANALYSIS

As a basis for this report, we searched the worldwide patent databases for inventions relating to vaccine technologies for the (+)ssRNA virus families: Coronaviridae, Togaviridae, Flaviviridae, Hepeviridae, Picornaviridae, Calciviridae, Arteriviridae and Asterioviridae. This search found 2076 unique Derwent World Patents Index (DWPI) patent families filed worldwide since 2000. For patent family definitions, see Appendix A: Definitions.

The search used a combination of keywords, International Patent Classification (IPC) symbols and Cooperative Patent Classification (CPC) symbols. Detail on the search methodology is provided in Appendix B: Search strategy.

Timeline

Analysing patent family filings over time can identify periods of growth or decline in patenting activity. This information can be useful for considering broader factors that may be influencing innovation in a given technology area.

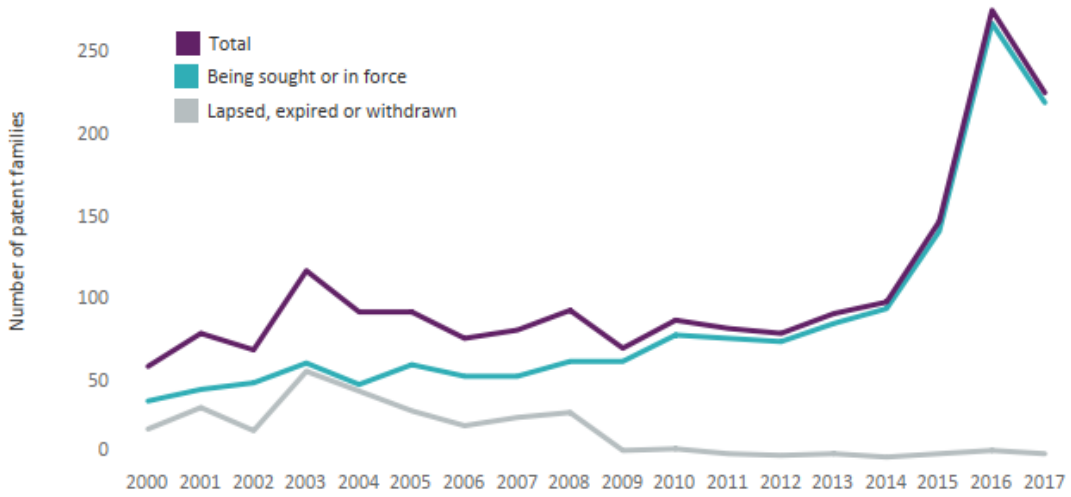
Figure 1 shows the number of patent families by their current legal status and earliest priority year. The legal status was divided into two categories: patents with at least one family member with protection actively being sought or in force (patent filed, accepted or granted), and patents with all family members lapsed, expired or withdrawn. Of the 2076 patent families filed since 2000, 1727 are in an active state (83 per cent) indicating a high commercial interest in vaccine technologies for (+)ssRNA viruses.

The timeline in Figure 1 shows that patent filing activity was relatively constant from 2000 to 2014 averaging around 84 new patent families per year. The peak in 2003-04 coincides with the coronavirus SARS outbreak, with 40 patent filings in this field alone.

Another peak from 2015-17 also coincides with disease outbreaks, with dominant numbers of patent filings related to Zika virus (Flaviviridae), foot-and-mouth disease virus (Picronaviridae) and porcine epidemic diarrhoea virus (PEDV) (Coronaviridae).

Figure 1: Patent families relating to vaccine technologies for (+)ssRNA viruses, by current legal status and earliest priority year

Source: Derwent World Patent Index (accessed 10 Dec 2019)



(Note: the data is not complete after 2016 due to the delay in patent publication, the decline in 2016-17 may be caused by the delay in publication and is not indicative of a trend).

In 2015 and 2016, filings increased to 147 and 274 patent families per year, respectively. This peak in filing activity represents a three-fold increase over the average number of filings seen from 2000–14. From 2000–15, applicants from the United States filed the highest number of patent families, 2–5 times more than filings from other jurisdictions. In 2016, Chinese applicants surpassed the United States as the highest filer with 144 patent families while United States applicants filed 54 families. In this year, over 50 per cent of filings from United States applicants were directed to vaccines against flaviviruses (such as Zika virus), whereas 64 per cent of filings from Chinese applicants were directed to vaccines against picornaviruses (such as foot-and-mouth disease virus) and coronaviruses (such as PEDV).

Filing destinations

The commercial markets or manufacturing destinations for inventions in any technology can be indicated by the jurisdictions in which patent applications are filed. Applicants must file patent applications in each patent jurisdiction where they wish to have patent protection. Figure 2 shows the top 15 filing jurisdictions for patent families relating to vaccine technologies for (+)ssRNA viruses and includes a map highlighting all jurisdictions where patents have been filed.

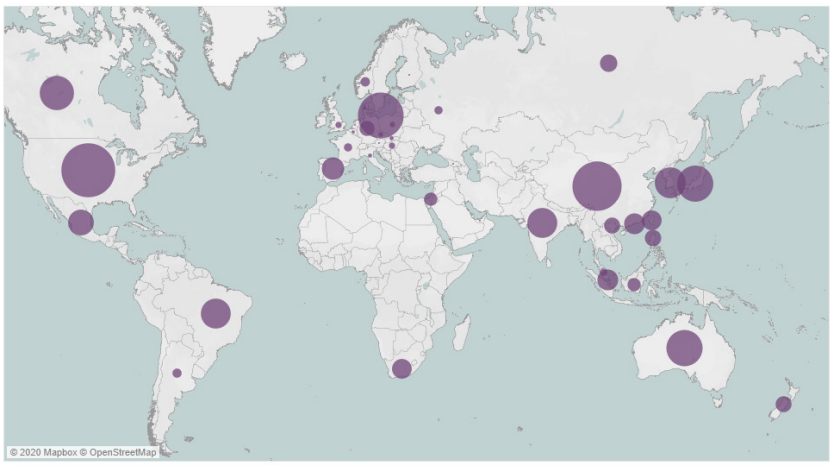
Patent Cooperation Treaty (PCT) applications are excluded from this figure because they do not represent an enforceable right in any jurisdiction. European patents are enforceable in designated contracting states to the European Patent Convention at the date of filing of the application and are included in this analysis.

Australia is the fourth largest target market for vaccine technologies related to (+)ssRNA viruses, with 550 patent families filed here. The United States is the largest target market, with 1219 patent families filed, followed by China (1015 patent families) and Europe (878 patent families).

Figure 2: Patent family filings relating to vaccine technologies for (+)ssRNA viruses by filing jurisdiction, 2000-19

Source: Derwent World Patent Index (accessed 10 Dec 2019)

UNITED STATES	1,219
CHINA	1,015
EUROPE	878
AUSTRALIA	550
JAPAN	547
CANADA	494
SOUTH KOREA	401
INDIA	376
BRASIL	370
MEXICO	279
SPAIN	211
SINGAPORE	182
HONG KONG	180
TAIWAN	164
SOUTH AFRICA	153
RUSSIAN FEDERATIO..	127
PHILLIPINES	113



Top applicants

A patent provides an exclusive monopoly to the applicant for 20 years over their invention, to protect their ideas and products. The number of patent families filed by an applicant in a particular technology can be indicative of their interest and market presence or desire to build and maintain a market share.

Figure 3 shows the top 10 applicants[3] for inventions relating to vaccine technologies for (+)ssRNA viruses. The top 10 applicants have contributed 502 patent family filings in total, including some co-filings, of which 429 patent families (85 per cent) remain active. This indicates that these patents are commercially valuable to these applicants.

United States Department of Health and Human Services

The United States Department of Health and Human Services is the top ranked applicant identified in this field, with 101 patent families filed since 2000. The United States Department of Health and Human Services is the principal government department for providing essential human services in the United States. In 2010, they developed a National Vaccine Plan with five overarching goals: develop new and improved vaccines; enhance the vaccine safety system; support communications to enhance informed vaccine decision-making; ensure a stable supply of access to, and better use of, recommended vaccines in the United States; and increase global prevention of death and disease through safe and effective vaccination.[5]

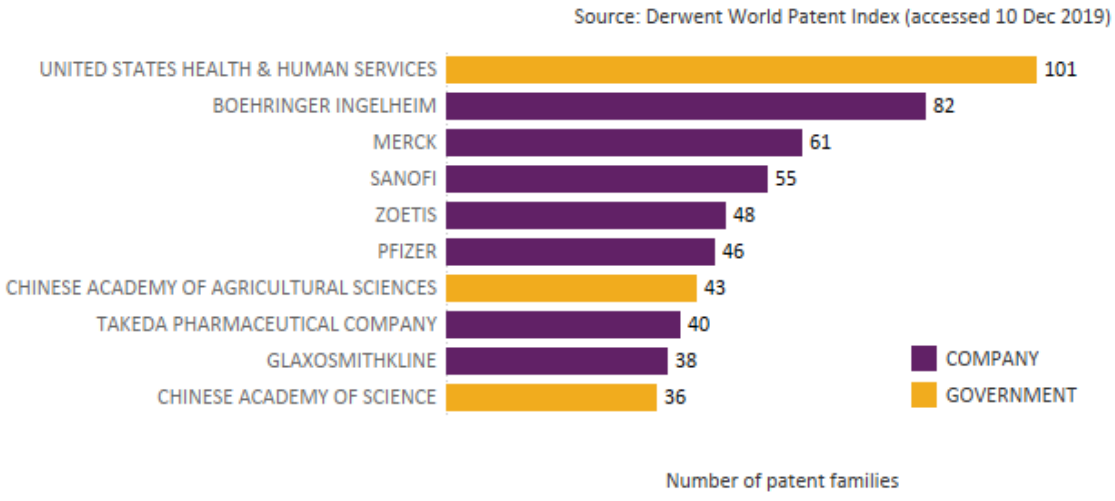
Their peak filing period was in 2016 with 18 patent families filed. They co-filed with Takeda Pharmaceutical Company (Takeda) on 10 patent families filed, while various universities appear as co-applicants on another 18 patent families.

Boehringer Ingelheim

Boehringer Ingelheim is the second ranked applicant identified, with 82 patent families. They are a global pharmaceutical company, with headquarters in Germany, and approximately 50 000 employees worldwide.[6] The company operates in three business areas: human pharmaceuticals, animal health and biopharmaceuticals.[7]

Boehringer Ingelheim's 82 patent families include filings by their animal health subsidiaries Vetmedica (46 patent families) and Merial (28 patent families). The peak filing periods for Boehringer Ingelheim were in 2011 and 2015, with 11 and 12 patent families filed respectively. Boehringer Ingelheim is an active filer in this technology with the most recent filing being in 2018.

Figure 3: Patent family filings relating to vaccine technologies for (+)ssRNA viruses, by applicant, 2000-19 [4]



[3] To provide an overview of the top players, applicants have been merged with their subsidiaries, where known, for this analysis
[4] Co-filings are counted for each co-owner. For instance, a patent application co-filed between the United States Health and Human Service and Takeda Pharmaceutical Company is counted once for both organisations.
[5] U.S. Department of Health and Human Services, U.S. National Vaccine Plan, https://www.hhs.gov/vaccines/national-vaccine-plan/index.html
[6] Boehringer Ingelheim, Locations, https://www.boehringer-ingelheim.com/locations/europe
[7] Boehringer Ingelheim, Our Company, https://www.boehringer-ingelheim.com/corporate-profile/our-company/organisation

Merck

Merck is a global healthcare company with headquarters in the United States. The company has three main business areas: pharmaceuticals, vaccines and animal health. Merck employed over 69 000 people and had revenue of 42.3 billion USD in 2018.[8]

This report identified 61 patent families filed by Merck since 2000 with 48 of those in the name of subsidiary Intervet International. The peak filing period for Merck was in 2014, with eight patent families. Merck has filed in this technology as recently as 2017.

Sanofi

Sanofi is a multinational pharmaceutical company with headquarters in Paris.[9] Sanofi Pasteur is their vaccines division. Each year, the company produces over a billion vaccine doses to immunise more than 500 million people worldwide against several diseases.[10]

This report identified 55 patent families filed by Sanofi since 2000 with 47 of those in the name of Sanofi Pasteur. Their peak filing period was in 2006 with nine patent families. Sanofi is an active filer with the most recent filings being in 2018.

Zoetis

Zoetis is a global animal health company formed in 2013 when Pfizer separated its animal health business into an independent company. With headquarters in the United States, the company develops, manufactures and commercialises veterinary medicines, vaccines and diagnostic products in over 100 countries.[11]

This study found 48 patent families filed by Zoetis since 2000. Their peak filing period was in 2008 with seven patent families filed in that year. Pfizer appears as a co-applicant in 50 per cent (24 families) of their patent filings.

Pfizer

Pfizer is a biopharmaceutical company with headquarters in New York. The company is engaged in the discovery, development and manufacture of health care products. Its global portfolio includes medicines and vaccines, as well as consumer health care products.[12] Pfizer employs over 92 000 people, has 58 manufacturing sites worldwide and had revenues of 53.6 billion USD in 2018.[13]

This study found 46 patent families filed by Pfizer since 2000. Their peak filing period was in 2005 with eight patent families. Their latest filing in this technology was in 2012. Subsidiaries of Pfizer that have filed patents relating to vaccine technologies for (+)ssRNA viruses include Wyeth (15 patent families), Coley Pharmaceutical Group (two patent families), Pharmacia Corporation (two patent families) and Fort Dodge Veterinaria (three patent families).

Chinese Academy of Agricultural Sciences

The Chinese Academy of Agricultural Sciences (CAAS) is a national agricultural scientific research organisation established in 1957. CAAS is headquartered in Beijing, and oversees 42 institutes.[14]

This study found 43 patent families filed by CAAS since 2000, with 42 of these filed in or after 2015. CAAS members who hold patent families include Lanzhou Veterinary Research Institute (30 families), Harbin Veterinary Research Institute (7 families) and Shanghai Veterinary Research Institute (4 families).

Takeda Pharmaceutical

Takeda is the largest pharmaceutical company in Asia. With headquarters in Japan, the company is engaged in research and development, manufacturing, sales and marketing and import/export of pharmaceutical drugs.[15]

This study found 40 patent families filed by Takeda, including the earlier mentioned 10 co-filings with the United States Department of Health and Human Services. Takeda Pharmaceutical subsidiaries include Inviragen (eight patent families) and Ligocyte (six patent families).

[8] Merck, https://www.merck.com/about/home.html
[9] Sanofi, https://www.sanofi.com/en/about-us
[10] Sanofi, Vaccines, https://www.sanofi.com.au/en/about-us/vaccines
[11] Zoetis, History, https://www.zoetis.com/about-us/history.aspx
[12] Pfizer Inc, https://www.reuters.com/finance/stocks/company-profile/PFE
[13] Pfizer, 2018 annual report https://s21.q4cdn.com/317678438/files/doc_financials/interactive_proxy/2019/images/Pfizer-Proxy2019.pdf
[14] Chinese Academy of Agricultural Sciences http://www.caas.cn/en/about_caas/basic_facts/index.html
[15] Bloomberg, Takeda Pharmaceutical Co Ltd, https://www.bloomberg.com/profile/company/4502:JP

Glaxosmithkline

With headquarters in the United Kingdom, Glaxosmithkline (GSK) is a multinational healthcare company with three business areas of focus: consumer healthcare, pharmaceuticals and vaccines.[16] GSK has over 2500 vaccine scientists working in three global research and development centres in Belgium, Italy and the United States.[17] In 2015, GSK acquired the vaccine business of Novartis (excluding influenza vaccines). This study found 38 patent families filed by GSK.

Chinese Academy of Sciences

Founded in 1949, the Chinese Academy of Sciences (CAS) comprises 104 research institutes, 12 branch academies, 3 universities and 11 supporting organisations in China. These house nearly 300 key laboratories and engineering centres, with a total of 1000 sites and stations. There are approximately 68 000 staff employed by CAS, and they implement 30 per cent of the 'Key Basic Science Projects' under China's 'National Basic Research Program'.[18]

This study found 36 patent families filed by CAS since 2000, with 27 patent families filed in 2016 or later. Members of CAS with patent filings relating to vaccine technologies for (+)ssRNA viruses include the Institute for Medical Biology (12 patent families), the Institut Pasteur of Shanghai (10 patent families), the Institute for Process Engineering (four patent families), the Institute of Microbiology (three patent families) and the Wuhan Institute of Virology (two patent families).

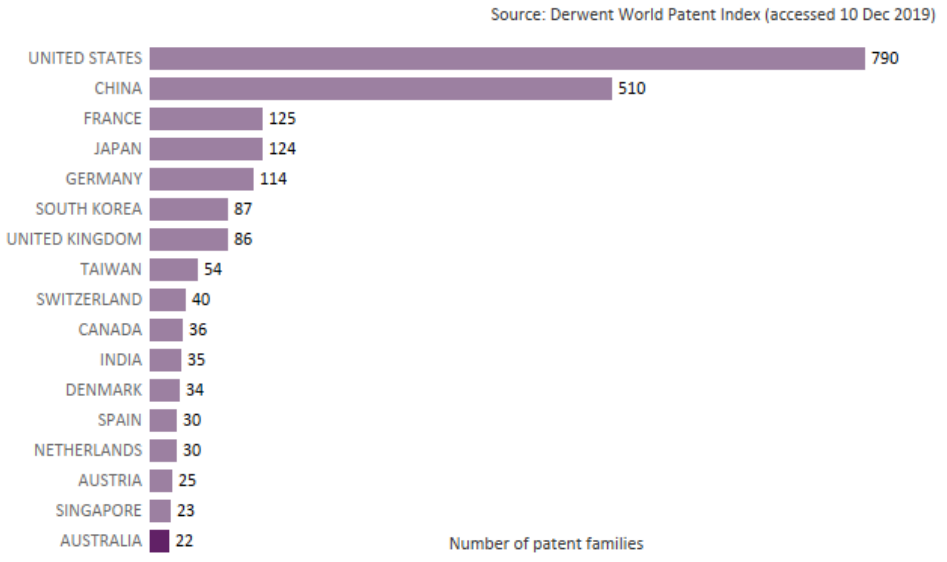
Applicant origin

Analysis of patent family applicant address indicates origins of investment or interest in a specific area of innovation. Figure 4 shows locations with the highest number of patent family filings relating to vaccine technologies for (+)ssRNA viruses originated.[19]

Australia ranks seventeenth globally for patent family filings, with 22 patent families filed by Australian applicants since 2000.

The United States is the dominant applicant origin for this technology field, with a total of 790 patent family filings or 38 per cent of total patent filings originating there. Of the top ten global applicants, four have headquarters the United States: the United States Department of Health and Human Services, Pfizer, Merck and Zoetis. Ranked in second place is China, with 510 patent families or 25 per cent of total filings. Two of the top ten applicants - CAAS and CAS - originate from China. France and Japan are ranked third and fourth respectively, each with six per cent of filings. A more detailed list of top applicants for the top four applicant origins can be found in Appendix C: Top Applicants by Region.

Figure 4: Patent family filings relating to vaccine technologies for (+)ssRNA viruses, by applicant origin, 2000-19 [20]

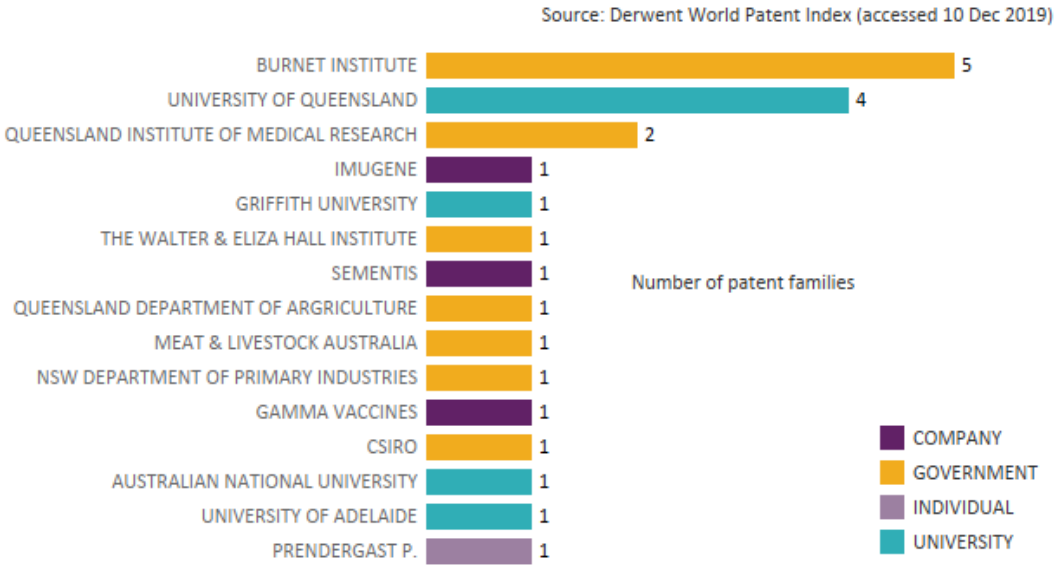


[16] GSK, https://www.gsk.com/en-gb/about-us/#tab-1-2
[17] GSK, Vaccines, https://www.gsk.com/media/5349/annual-report-2018.pdf
[18] Chinese Academy of Sciences, http://english.cas.cn/about_us/introduction/201501/t20150114_135284.shtml
[19] Applicant origin information is derived from applicant address data and harmonisation where possible
[20] If a single patent filing has applicants from different locations, the patent will be counted once for every applicant origin listed on the patent

Australian applicants

To better understand Australian patenting activity, we analysed data relating to Australian applicants (Figure 5). Australian entities filed a total of 22 patent families, with 15 separate applicants. This includes one patent family co-filed by the Queensland Department of Agriculture and Meat & Livestock Australia. The top Australian filer is the Burnet Institute (five patent families) followed by the University of Queensland (four patent families) then the Queensland Institute of Medical Research (two patent families). The other 12 Australian entities that filed patent applications directed to vaccine technologies for (+)ssRNA viruses each filed one patent family. These Australian entities are discussed in more detail below.

Figure 5: Patent family filings relating to vaccine technologies for (+)ssRNA viruses by Australian applicants, 2000-19 [4]



Burnet Institute

Burnet Institute, formerly The Macfarlane Burnet Institute for Medical Research and Public Health, is the top Australian applicant, with five patent families. The Burnet Institute a not-for profit independent organisation whose purpose is to improve the health of disadvantaged or otherwise vulnerable communities in Australia and internationally through research, education and public health.[21] Their patent families identified in this study are directed towards vaccines against hepatitis C virus (WO2007128048, WO2008022401, WO2012068637, WO2006021048, WO2018058177).

University of Queensland

Founded in 1909, the University of Queensland is one of Australia's leading research and teaching institutions. The University has a strong focus on research activities divided among eight research institutes. The University is also a partner in the Translational Research Institute, a recently established institute with the capacity to discover, produce, test and manufacture new treatments and vaccines in one location.[22]

This study found four patent families belonging to the University of Queensland: WO2015089590 directed to a vaccine against bovine viral diarrhoea virus comprising silica vesicles, WO2018176103 directed to subunit vaccines comprising chimeric polypeptides based on viral membrane fusion proteins from a variety of virus classes including coronaviruses, WO2005042014 directed to an isolated nucleic acid vaccine composition that encodes an attenuated Kunjin virus that can elicit an immune response against West Nile virus, and WO2018176075 directed to chimeric proteins

[21] The Burnet Institute, https://www.burnet.edu.au/about
[22] The University of Queensland, https://www.uq.edu.au/about/university-profile

capable of forming a virus particle that comprise one or more amino acid sequences of an insect-specific flavivirus and one or more other immunogenic proteins, including other flavivirus proteins.

Queensland Institute of Medical Research

The Queensland Institute of Medical Research (QIMR) is a medical research institute with headquarters in Brisbane. With over 600 staff members, QIMR has an infectious disease research division that includes research on variety of mosquito-borne viruses such as CHIKV.[23]

This study found two patent families filed by QIMR: WO2002088177 directed to a subunit vaccine against equine rhinitis A virus comprising the VP1 polypeptide from the virus, and WO2004014957 directed to a vaccine against hepatitis C virus comprising synthetic immunogenic lipopeptide molecules containing co-linear T-helper and CTL epitopes.

Imugene

Imugene is an Australian company with a focus on immuno-oncology treatments.[24] In this study there is one patent family owned by Imugene (WO2011147002), which discloses an attenuated porcine adenovirus 3 based vaccine for the treatment of porcine reproductive and respiratory syndrome virus infection. This patent was filed by Vectogen, an Australian research and development company aimed at commercialising a range of animal health technologies including an adenoviral delivery vector platform licensed from the Commonwealth Scientific and Industrial Research Organisation (CSIRO).[25] Vectogen was acquired by Imugene in 2003,[26] and subsequently deregistered in 2015.

Griffith University

Griffith University comprises six campuses across South East Queensland and has over 50 000 students.[27] Research at Griffith University is conducted through a network of research centres and institutes, which span a diverse array of disciplines, including infectious disease and immunology.[28] This study identified one patent family filed by Griffith University; WO2017201579 directed to a vaccine comprising live attenuated recombinant alphaviruses (including CHIKV) containing a mutated capsid protein.

The Walter and Eliza Hall Institute

The Walter and Eliza Hall Institute (WEHI) is Australia's oldest medical research institute.[29] WEHI has a focus on three major health challenges: cancer, immune health and infection, and development and ageing.[30] This study identified one patent family filed by WEHI, WO2007134385 directed to immunogenic compositions comprising a viral peptide/protein antigen and a targeting moiety specific for lymph-resident dendritic cells. The viral antigen can be derived from a variety of viruses including togaviruses.

Sementis

Sementis is an Australian unlisted public biotechnology company that has developed a proprietary vaccine delivery platform based on an attenuated smallpox virus.[31] The company is currently using the platform to develop vaccines against peanut allergy, cat allergy, CHIKV and Zika virus. Patent WO2018032057, filed by Sementis, discloses a vaccine against CHIKV comprising an attenuated poxvirus, in which the poxvirus genome comprises a heterologous nucleic acid sequence encoding the 26S subgenomic polyprotein of CHIKV.

Queensland Department of Agriculture

The Queensland Department of Agriculture and Fisheries (DAF), works to achieve a productive and profitable agriculture, fisheries and forestry sector by promoting sustainability and innovation.

This study found one patent family filed by DAF: WO2013003904 discloses a recombinant, low virulence bovine herpesvirus 1 vaccine vector engineered to express heterologous antigens from other virus pathogens including bovine viral diarrhoea virus. Meat & Livestock Australia were a co-applicant on this patent family.

[23] QIMR Berghofer Medical Research Institute, https://www.qimrberghofer.edu.au/about-us/
[24] https://www.sharecafe.com.au/2015/07/22/b-cells-the-big-sell-for-imugene/
[25] https://www.cabi.org/agbiotechnet/news/1679
[26] https://hotcopper.com.au/threads/bit-of-movement-today.39125/page-2
[27] Griffith University, https://www.griffith.edu.au/about-griffith
[28] Griffith University, https://www.griffith.edu.au/research/centres-institutes
[29] Walter and Eliza Hall Institute of Medical Research, https://www.wehi.edu.au/
[30] Walter and Eliza Hall Institute of Medical Research, About, https://www.wehi.edu.au/about
[31] https://www.sementis.com.au/about-us

Meat & Livestock Australia

Meat & Livestock Australia (MLA) was established in 1998 as a public company limited by guarantee. MLA fosters the long-term prosperity of the Australian red meat and livestock industry by delivering research and development that contributes to producer profitability, sustainability and global competitiveness.[32] MLA invests up to $7 million a year in animal health, welfare and biosecurity research and development projects.[33] They co-filed WO2013003904 with the Queensland Department of Agriculture.

New South Wales Department of Primary Industries

The New South Wales Department of Primary Industries (DPI) has six core divisions: Agriculture; Fisheries; Biosecurity and Food Safety; Strategy, Policy and Engagement; Investment and Business Development; and Research Excellence. DPI's research and development hub maintains a portfolio of $100 million per year of research and development projects.[34] This study found one patent family filed by DPI, WO2007121522 directed to vaccine therapeutics derived from a pestivirus strain associated with porcine myocarditis syndrome.

Gamma Vaccines

Gamma Vaccines is an Australian company, formed in 2009, that utilises gamma irradiation to inactivate viruses for vaccine purposes. This study found one patent family filed by Gamma Vaccines (WO2012100302), directed to combination vaccines with a gamma-irradiated influenza virus and an immunogen derived from another microorganism such as togaviruses.

CSIRO

CSIRO is Australia's largest public research organisation with around 5500 employees and a funding budget of approximately $600 million.[35] This study identified one patent family co-filed by CSIRO and the University of Georgia, WO2017088017, disclosing an avian egg that has been genetically modified to reduce the expression of an antiviral gene, which permits more efficient production of viral particles for vaccine purposes.

Australian National University

The Australian National University (ANU) was founded by the Australian Government in 1946. The University has over 25 000 students and conducts health and medical research in a variety of disciplines.[36] This study identified one patent family filed by ANU, WO2013188918 directed to vaccines comprising attenuated flaviviruses for stably expressing heterologous nucleic acid molecules encoding antigens from a variety of flaviviruses including dengue virus, Japanese encephalitis virus, yellow fever virus, Murray Valley encephalitis virus, West Nile virus and St Louis encephalitis virus.

University of Adelaide

Founded in 1874, the University of Adelaide is Australia's third-oldest university. The University has over 4000 research staff and students across four main precincts that include seven institutes and over 50 specialist research centres.[37] This study found one patent family filed by the University of Adelaide, WO2013170305, which discloses a method for inducing or enhancing an immune response against an immunogen in a subject whereby an antigen presenting cell is modified to express the immunogen on its surface before administration. The immunogen may be derived from hepatitis C virus.

Individual applicants

There was one patent family filed by an individual with an Australian address. WO2016001907, filed by Patrick Prendergast, discloses vaccine compositions comprising an antigen combined with Mogroside IV as an immune stimulatory adjuvant, with the antigen selected from hepatitis C or dengue virus.

[32] MLA, https://www.mla.com.au/about-mla/mla-at-a-glance/how-we-deliver/
[33] MLA, https://www.mla.com.au/research-and-development/animal-health-welfare-and-biosecurity/
[34] https://www.dpi.nsw.gov.au/about-us/science-and-research
[35] CSIRO 2018 Annual report, https://www.csiro.au/~/media/About/AnnualReport/Files/2017-18/18-00410_CORP_AnnualReport2017-18_WEB_180928.pdf?la=en&hash=38A094CABD16B4D934CD44C309B8F95CB700F78E
[36] ANU, https://www.anu.edu.au/about/quick-statistics
[37] University of Adelaide, https://www.adelaide.edu.au/research/about-us/institutes-centres

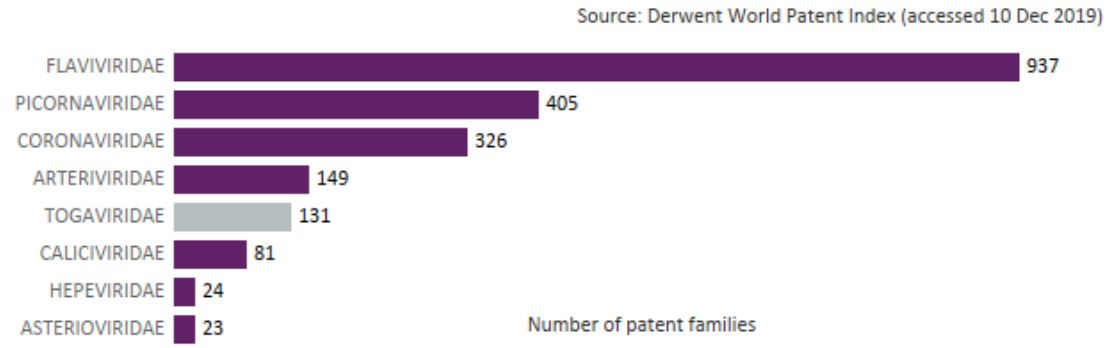
(+)SSRNA VIRUS VACCINE TARGETS

Vaccines for (+)ssRNA viruses are directed against specific viral species. Here we have analysed the patent dataset to determine which (+)ssRNA viruses are described as vaccine targets. This analysis can help to understand areas of commercial interest and can inform commercialisation strategies and research directions. For a detailed description of the method of technology classification used, please see Appendix D: Technology analysis.

We divided the 2076 patent families into eight categories based on the viral family classification of the vaccine target. Each category is based on patent classification symbols (IPC and CPC) and keywords (see Appendix D for more information about the technology classification).

A brief discussion of the patenting activity for each virus family is given below, except for the togaviruses, which are discussed in more detail in the next section.

Figure 6: Virus families targeted by vaccines for (+)ssRNA viruses, 2000-19



Flaviviridae

Viruses from the Flaviviridae family, such as dengue, Zika, Japanese encephalitis, West Nile and yellow fever, were the most common targets of vaccine technologies for (+)ssRNA viruses with 937 patent families. From 2000–15, on average of 43 patent families were filed each year for vaccines against Flaviviridae. In 2016 and 2017, filings increased to 106 and 73 patent families, respectively. Most of these patents (40 per cent) were directed to vaccines against Zika virus. The United States Department of Health and Human Services was the top applicant during at this time, with 14 patent families filed and all directed to Zika virus vaccines.

Picornaviridae

Viruses from the Picornaviridae family were the second most common targets of vaccine technologies for (+)ssRNA viruses with 405 patent families. From 2000–15, an average of 14 patent families were filed each year for vaccines against Picornaviridae. In 2016 and 2017, filings increased to 71 and 74 patent families respectively, and most of these patents (51 per cent) were directed to vaccines against foot-and-mouth disease virus. The leading applicants in 2016–17 were CAAS (16 patent families) and the United States Department of Health and Human Services (10 patent families).

Coronaviridae

Viruses from the Coronaviridae family were the third most common targets of vaccine technologies for (+)ssRNA viruses (326 patent families in total). For this technology area, two peaks in filing activity were observed: 2003 and 2004 (38 and 29 families respectively) and 2016 and 2017 (54 and 46 families respectively). Sixty-five per cent of coronavirus patent families filed in 2003–04 were directed to vaccines against SARS virus, while 40 per cent of coronavirus patent families filed in 2016–17 were directed to PEDV.

Arteriviridae

Viruses from the Arteriviridae family were the fourth most common targets of vaccine technologies for (+)ssRNA viruses (149 patent families in total). From 2000–18, eight patents were filed per year, on average, related to vaccines directed against Arteriviridae. Of the 149 patent families, 72 per cent were directed to vaccines against porcine reproductive and respiratory syndrome virus (PRRSV). Boehringer Ingelheim was the top applicant with 29 patent families filed, including 27 patent families directed to PRRSV vaccines.

Caliciviridae

Eighty-one patent families were directed toward the Caliciviridae family with an average of 4.5 filings per year. These patent families predominantly focused on norovirus (38 per cent) and feline calicivirus (23 per cent). Boehringer Ingelheim was the top applicant filing eight patent families, including seven directed to feline calicivirus vaccines.

Hepeviridae

Twenty-four patent families were directed toward the Hepeviridae family with the majority of these (16 families) filed from 2010–18. Most of the patents (79 per cent) were directed to vaccines against hepatitis E virus.

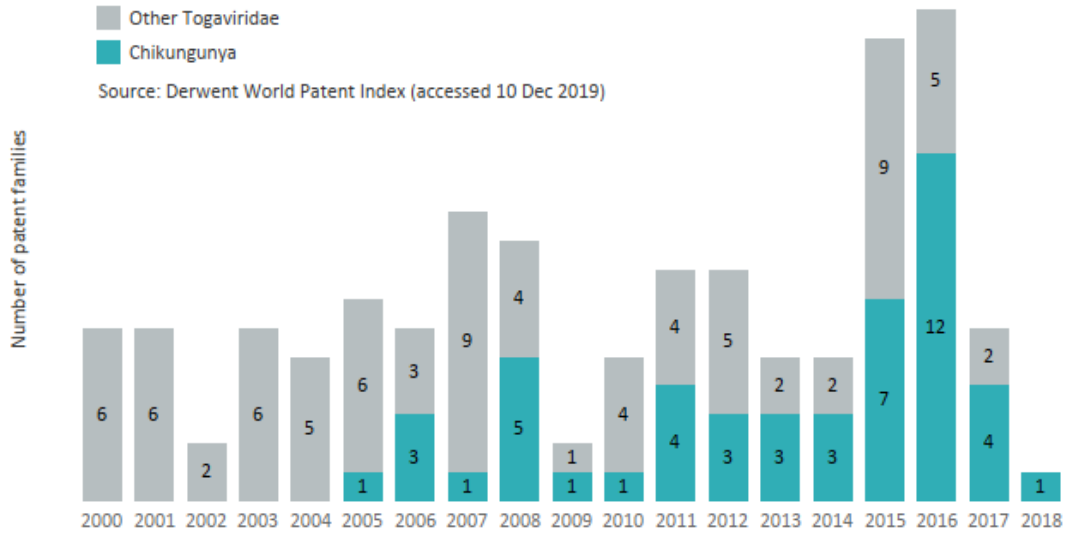
Asterioviridae

In total, 23 patent families were filed that were directed to the Asterioviridae family. Across most of the time period there were low numbers of filings, with a peak of seven filings in 2018. All filings in 2018 were directed to vaccines against a newly identified astrovirus believed to be the cause of goose gout.

TOGAVIRUS AND CHIKV VACCINES

Togaviruses were the fifth most common targets of vaccine technologies for (+)ssRNA viruses, with 131 patent families filed (Figure 6), of which 49 patent families (37 per cent) were directed to CHIKV vaccines. On average, six patents on Togaviridae vaccines were filed each year from 2000–14 (Figure 7). In 2015 and 16, filings increased to 16 and 17 patent families, respectively. Twenty-four of the 40 families filed from 2015–18 were directed to CHIKV vaccines.

Figure 7: Patent families relating to vaccine technologies for Togaviridae and CHIKV, by earliest priority year, 2000-19

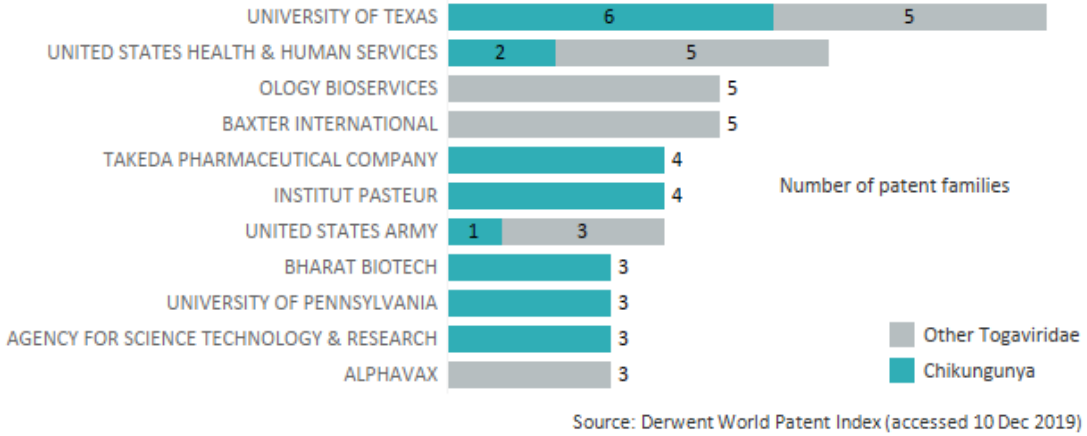


(Note: the data is not complete after 2016 due to the delay in patent publication).

Top applicants for togavirus and CHIKV vaccines

The top global applicants, with three or more patent family filings each for vaccine technologies for Togaviridae and CHIKV are shown in Figure 8.

Figure 8: Patent family filings relating to vaccine technologies for Togaviridae, by applicant, 2000-19



Source: Derwent World Patent Index (accessed 10 Dec 2019)

University of Texas

The University of Texas System is a state university system that oversees 13 educational institutions including eight universities and five independent health institutions.[38] This study found 24 patent families in total filed by the University of Texas, of which 11 are directed to inactivated/attenutated vaccine technologies against Togaviridae. Six patents disclosed vaccines directed to CHIKV.

United States Department of Health and Human Services

As discussed previously, the United States Department of Health and Human Services is the top ranked applicant identified in this report, with 101 patent families filed since 2000. Of these, seven patent families disclosed vaccine technologies directed against Togaviridae, with two directed to CHIKV vaccines.

Ology Bioservices

Ology Bioservices is a company based in the United States focused on biopharmaceutical development and manufacturing. The company has several vaccine production systems that use their Veroplex™ proprietary Vero cell platform technology to manufacture vaccines for a range of viral pathogens including Ross River virus, CHIKV, West Nile virus and norovirus.[39] This study found six patent families filed by Ology Bioservices, five disclosing vaccines directed against Togaviridae.

Baxter International

Baxter International is a global healthcare company with headquarters in the United States. This study found seven patent families filed by Baxter International, five of which disclose vaccines directed against Togaviridae.

Takeda Pharmaceutical Company

As discussed previously, Takeda is the eighth ranked top applicant identified in this report, with 41 patent families filed since 2000. Four of these patent families disclose vaccines directed to CHIKV.

Institut Pasteur

The Institut Pasteur is a private, non-profit foundation located in France with four main areas of focus: research, education, population health and innovation development. The institute comprises 133 research units in Paris and 32 institutes at various locations around the world.[40] It co-founded the Institut Pasteur of Shanghai with the Chinese Academy of Science and the Shanghai Municipal Government in 2004.[41] Patents filed by the Institut Pasteur of Shanghai have been attributed to CAS. This study found 32 patent families filed by Institut Pasteur overall; four disclosed vaccines directed against CHIKV.

United States Army

The United States Army includes the United States Medical Research Institute of Infectious Diseases, the Army's lead facility for medical biological research. It is located at Fort Detrick, Maryland. This study found a total of 12 patent families filed by the United States Army, of which four were for vaccines directed against Togaviridae and one was for CHIKV specifically.

Other applicants

Other applicants with three patent families each that disclosed vaccines for Togaviridae viruses include the University of Pennsylvania, the Indian biotechnology company Bharat Biotechnology, the Agency for Science, Technology and Research based in Singapore and the United States based company Alphavax.

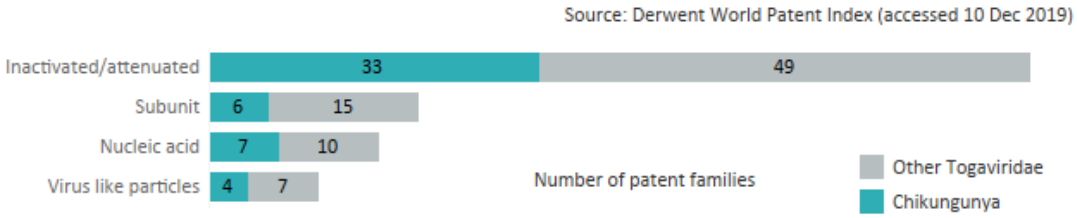
[38] UT System, https://www.utsystem.edu/institutions
[39] Ology Bioservices, https://www.ologybio.com/vaccine-contract-partnering-licensing/
[40] Institut Pasteur, https://www.pasteur.fr/en/our-missions
[41] Institut Pasteur Shanghai; http://english.shanghaipasteur.cas.cn/Overview2016/bi2016/

Types of vaccines for togavirus and CHIKV

Patent families on vaccines against togaviruses and CHIKV have been divided into four technology categories based on their physical type: inactivated/attenuated, subunit, nucleic acid, and virus like particles (Figure 9). This categorisation uses patent classification symbols (IPC and CPC) and keywords (see Appendix C for more information about the technology classification).

The technology with the most patent families is inactivated/attenuated vaccines with 82 patent families in total, 33 directed against CHIKV. Subunit vaccines are next with 19 patent families (6 directed against CHIKV). Patents directed to nucleic acid-based vaccines are the third ranked category (17 patent families in total, 7 directed to CHIKV) and patents for vaccines utilising virus like particles (VLP) are the fourth ranked category (11 patent families in total, 4 directed to CHIKV).

Figure 9: Patent family filings relating to vaccine technologies for Togaviridae viruses, by type of vaccine, 2000-19



Inactivated/attenuated vaccines include vaccines comprising either inactivated or attenuated Togaviridae particles or attenuated heterologous virus particles expressing antigens from Togaviridae. Examples of patent applications in this category include:

- WO2009131604, filed by the University of Texas, discloses an attenuated recombinant alphavirus (including CHIKV) that is incapable of replicating in mosquito cells and of transmission by mosquito vectors. The attenuation is generated by cloning an internal ribosomal entry site of encephalomyelocarditis virus between the end of the non-structural protein 4 coding sequence and a subgenomic RNA coding sequence of the alphavirus.
- WO2019057793, filed by Valneva, details a vaccine comprising live attenuated CHIKV particles that are produced by a process that minimises the presence of immunogenicity-reducing mutations in the viral genome, particularly mutations in the E2 protein.
- WO2017197035, filed by Najit Technologies, describes a method for producing an immunogenic vaccine composition comprising an inactivated pathogen (including CHIKV) where the method contacts the pathogen with a Fenton reagent including hydrogen peroxide and a transition metal to render the pathogen non-infectious while retaining pathogen immunogenicity.
- CN109536464A, filed by the Chinese Academy of Science, discloses an attenuated CHIKV containing a mutated capsid protein.

Subunit vaccines include vaccines with protein subunits of Togaviridae virus particles. Examples of patent applications in this category include:

- WO2019136316, filed by the University of Washington, discloses a fusion protein with an Fc region and at least one matrix remodelling-associated protein (Mxra) 8 region having Mxra8 activity or Mxra8 receptor activity which can be used to treat a Mxra8-associated alphavirus infection, including a CHIKV infection.
- WO2017009873, filed by Bharat Biotechnology, discloses vaccine compositions with Zika virus antigens in combination with other arbovirus antigens such as CHIKV or Japanese encephalitis virus antigens.
- WO2016122414, jointly filed by the Agency for Science, Technology and Research and Nanyang Technological University, discloses a vaccine composition with a peptide epitope from CHIKV enclosed within a self-assembling protein nanocapsule made from ferritin.

Nucleic acid vaccines include vaccine compositions that include nucleic acids. Examples of patent applications in this category include:

- WO2017015463, filed by Moderna Therapeutics, discloses a CHIKV vaccine with a ribonucleic acid (RNA) polynucleotide with an open reading frame encoding at least one CHIKV antigenic polypeptide or immunogenic fragment.
- WO2017165460, filed by the University of Pennsylvania, discloses combination DNA vaccines with recombinant nucleic acid sequences encoding synthetic antibodies and viral antigens, including CHIKV antigens.
- WO2018020271, filed by the University of Oxford, discloses a DNA vaccine with recombinant nucleic acid sequences encoding Zika virus antigens together with CHIKV antigens.

Virus like particle (VLP) vaccines are multiprotein structures that mimic the organisation and conformation of native viruses but are non-infectious as they are devoid of nucleic acids. Patents in this category are directed to vaccine compositions comprising VLPs. Examples include:

- WO2010062396, filed by the United States Department of Health and Human Services, discloses a VLP with CHIKV structural polypeptides selected from the capsid and envelope proteins E3, E2, 6K and E1.
- WO2012106356, filed by the United States Department of Health and Human Services, discloses a VLP comprising a modified CHIKV E2 structural polypeptide that promotes more efficient VLP production.
- WO2014049094, jointly filed by Centre National de la Recherche Scientific, Institut Pasteur and Themis Bioscience, discloses a heterologous measles VLP containing CHIKV envelope and capsid proteins on the surface of the particle.
- WO2017066484, filed by Daniel Carter, discloses a fusion protein comprising a self-assembling coronavirus NSP10 protein and a protein or peptide capable of being fused to NSP10 without interfering with the assembly or aggregation of the resulting fusion protein. The protein fused to NSP10 can be derived from CHIKV and may be a VLP.

CONCLUSION

This report analyses patent filings relating to vaccine technologies for (+)ssRNA viruses, with an emphasis on togaviruses and CHIKV. In this area, a total of 2076 patent families have been filed since 2000. Steady filing activity over time for vaccine technologies for (+)ssRNA viruses indicates this is an area of ongoing active innovation.

There are also spikes in filings corresponding with disease outbreaks. For example, patent filings in 2015–16 increased three-fold, with growth being driven by applicants from the United States and China. Fifty-two per cent of the recent filings from United States applicants were related to vaccines against the Flaviviridae (such as Zika virus) whereas 64 per cent of recent filings from Chinese applicants were directed to vaccines against the Picornaviridae and Coronaviridae (such as foot-and-mouth disease virus and PEDV, respectively). Furthermore, these three virus families were also the top three vaccine targets overall.

Australia is the fourth largest patent filing destination with 27 per cent of patent families filed here, indicating that the Australian population will have access these vaccines, while Australian applicants rank seventeenth for filings relating to vaccine technologies for (+)ssRNA viruses. The United States and China are the first and second ranked filing destinations and applicant origins respectively.

Viruses from the Togaviridae family were the fifth most common targets of vaccine technologies for (+)ssRNA viruses, with 131 patent families. Of the 131 patent families, 49 (37 per cent) were related to CHIKV vaccines. The University of Texas was the leading applicant for vaccines against Togaviridae (11 patent families) with 6 of these directed to CHIKV specifically. Only two Australian applicants, Sementis and Griffith University, were found to have filed patents related to CHIKV vaccines.

Various different types of CHIKV vaccines were produced, with attenuated/inactivated compositions being the most common. Overall patent filings for CHIKV vaccines have been steady since 2005 with an increase in 2015–16, indicating that CHIKV vaccine development remains an active area for innovation.

APPENDIX A: DEFINITIONS

Patent, applications and publications

A patent is a right that is granted for any device, substance, method or process that is new, inventive and useful. Australian patent rights are legally enforceable and give the owner, or patentee, exclusive rights to commercially exploit the invention in Australia for a period of up to 20 years. In this report, an application refers to a single patent filing. A patent application is usually published within 18 months of its earliest filing date (also known as the priority date). We consider that the priority date is most relevant for our analysis as it is the closest date to that when the invention occurred.

There are two major routes for filing a patent application: international route and direct filing. The international route involves filing a PCT application, which establishes a filing date in all 152 contracting states.[42] Subsequent prosecution at national patent offices, referred to as national phase entry, is made at the discretion of the applicant. A patent can only be enforced once it has been granted and a PCT application must enter the national phase to proceed towards grant. Alternatively, applications can be filed directly in the jurisdictions of interest.

Patent families

Applications filed in different jurisdictions but claiming the same priority are known as patent families. Patent families enable us to analyse inventive activity regardless of the number of jurisdictions in which protection is sought. Patent families are commonly used in analytics as they generally represent a single invention. In this analysis, we determined patent families based on DWPI database definition. In a DWPI patent family each member shares exact priorities with each and every other family member.[43] The DWPI database also contains INPADOC patent families, which give a unique family ID to patents that share a common priority document.[44] For metrics, the number of patent families is typically used. There are some exceptions where individual applications are reported on, as each application represents a legal right in an individual jurisdiction. When analysing the number of applications or families per applicant, relating commercial entities have been grouped under a single, optimised assignee name as assigned in the Derwent DWPI database. When individual publication numbers are quoted, we have chosen a representative publication from the respective patent family.

Classification

Patents are hierarchically classified by technology into the hierarchical IPC or CPC systems. The CPC began in 2013 and provides significantly more depth to the hierarchy of the IPC.[45] For more information on the coverage of the CPC, see the CPC Annual Report 2016.[46]

[42] WIPO, www.wipo.int/pct/en/pct_contracting_states.html
[43] Derwent Innovation: DWPI and INPADOC Family Criteria, https://support.clarivate.com/Patents/s/article/Derwent-Innovation-DWPI-and-INPADOC-Family-Criteria?language=en_US
[44] Martinez, 'Insight into Different Type of Patent Families', OECD Science, Technology and Industry Working Papers, No. 2010/2, OECD Publishing, Paris; see section 3.2, 'Extended families'.
[45] European Patent Office and United States Patent and Trademark Office, www.cooperativepatentclassification.org/
[46] EPO and USPTO, www.cooperativepatentclassification.org/publications/AnnualReports/CPCAnnualReport2016.pdf

APPENDIX B: SEARCH STRATEGY

Searching patent information to identify relevant records for analysis requires a stepped approach to identify broad categories of relevance, and then specific records within them that meet the technology brief.

The following outlines the detail of the search and analysis process conducted.

Data extraction and analysis

We used five phases of data extraction and analysis.

- Phase 1: Development of a search strategy (below).
- Phase 2: Data mining using the DWPI database accessed via Derwent Innovation. The unique patent publications relating to vaccine technologies for positive-sense single-stranded RNA viruses were identified and used to extract information related to their DWPI family from Derwent Innovation
- Phase 3: Data cleaning, focusing on consolidating applicant names and ensuring the return of correct records. Data categorisation according to the technological focus of the patent families. The technological focus was determined by using CPC/IPC symbols and/or key words as required.
- Phase 4: Data captured in the search that was not directed to vaccine preparations against any of the eight families of (+)ssRNA viruses were excluded from the analysis.
- Phase 5: Data analysis using Tableau 2019.3 for calculation and visual presentation of patent metrics.

Search strategy

The search used CPC/IPC symbols and keywords and was limited to patent applications that had an earliest filing date between 2000 and 2019.

Search statement combination:

((1.1 OR 1.2) AND 1.3) AND 1.4

Statement	Search query
1.1	CTB=(((Ross ADJ River) OR chikungunya OR (Barmah ADJ Forest) OR getah OR (semliki ADJ forest) OR (Eastern ADJ Equine ADJ Encephalitis) OR alphavir* OR Togavir* OR Dengue OR Zika OR (Japanese ADJ encephalitis ADJ virus) OR (west ADJ nile) OR ntaya OR (yellow ADJ fever) OR flavivir* OR hepacivir* OR (hepatitis ADJ ("C" OR "G" OR "A")) OR Picornavir* OR enterovirus* OR rhinovirus* OR hepatovir* OR Astrovir* OR mamastovir* OR avastrovir* OR Calicivir* OR (Rabbit ADJ hemorrhagic ADJ disease ADJ virus) OR norovir* OR Hepevir* OR Arterivir* OR Coronavir* OR Nidovir* OR (foot ADJ "and" ADJ mouth ADJ disease ADJ virus) OR pestivir* OR Parechovir* OR Poliovir* OR Apthovir* OR Cardiovir* OR (encephalomyocarditis ADJ virus)) NEAR12 (vaccine*1 OR vaccination*1 OR immunogen*1 OR (immunogenic NEAR3 composition*1)));
1.2	CPC=((C12N2770???23) OR (C12N2770???6?) OR (C12N2770???34)) AND CTB=(vaccine*1 OR vaccination*1 OR immunogen*1 OR (immunogenic ADJ composition*1) NEAR12 (virus or viral OR viruses)) NOT CPC=((C12N277014???) OR (C12N277018???) OR (C12N277022???) OR (C12N277030???) OR (C12N277034???) OR (C12N277038???) OR (C12N277040???));
1.3	CPC=(A61K2039* OR C12N2770* OR C12N2790* OR C12N2799*);
1.4	(PRD>=(20000101) AND PRD<=(20190819));

* denotes a wildcard, for any suffix or prefix variation when placed at the end or start respectively.? denotes a wildcard which indicates the presence of either zero or exactly one character. *n (e.g. *2) denotes a wildcard with between zero and n characters. CPC indicates that current CPC classifications were searched, CTB indicates the titles, abstracts and claims were searched and PRD indicates.

APPENDIX C: TOP APPLICANTS BY REGION

Figure 10 shows the top ten applicants for inventions relating to vaccine technologies for (+)ssRNA viruses for the United States (A), China (B), France (C) and Japan (D). Entities from these regions filed 790, 510, 125 and 124 patent families, respectively.

Figure 10: Patent family filings relating to vaccine technologies for (+)ssRNA viruses by applicants from the United States (A), China (B), France (C) and Japan (D), 2000-19.

APPENDIX D: TECHNOLOGY ANALYSIS

Technology categorisation

A technology categorisation was conducted using a combination of CPC/IPC classification symbols and keywords. The table below provides the IPC or CPC subclasses captured in each technology area and the keywords identified in the abstract or title or claims.

A patent family will only appear in one category. Patents that disclosed vaccine technologies directed to viruses from multiple families were rank classified based on the order of the virus families listed in the table below.

Virus family	IPC/CPC symbols	Keywords	Priority
Togaviridae	C12N277036???	Togavir* (Ross River), chikungunya OR (Barmah Forest), getah, (semliki forest), (Eastern Equine Encephalitis), alphavir*), Rubella	1
Flaviviridae	C12N277024???	Flavivir*, Dengue, Zika, (Japanese encephalitis virus), (west nile), ntaya, (yellow fever), hepacivir*, pestivir*, (hepatitis (“C” OR “G”))	2
Coronaviridae	C12N277020???	Coronavir*, Severe acute respiratory syndrome, SARS, Nidovir*, Middle East respiratory syndrome, MERS, Apthovir*, Cardiovir*, encephalomyocarditis	3
Hepeviridae	C12N277028???	Hepevir*	4
Picornaviridae	C12N277032???	Picornavir*, enterovirus*, rhinovirus*, hepatovir*, (foot and mouth disease virus), (hepatitis (“A”), Poliovir*, Parechovir*, Coxsackie*	5
Caliciviridae	C12N277016???	Calicivir*, Rabbit hemorrhagic disease virus, norovir*	6
Arteriviridae	C12N277010???	Nidovir*, porcine reproductive and respiratory syndrome	7
Asterioviridae	C12N277012???	Astrovir*, mamastovir*, avastrovir*	8

* denotes a wildcard, for any suffix or prefix variation when placed at the end or start respectively

Vaccine technology	IPC/CPC symbols	Keywords
Chikungunya	C12N2770/36???	Chikungunya, CHIKV
Inactivated/ Attenuated	C12N2770/???6? OR A61K2039/5254 OR A61K20395252 OR C12N704??? C12N2770???34	
Subunit	C12N2770???34	Protein, glycoprotein, subunit, peptide, polypeptide, antigen
Nucleic Acid	A61K203953	DNA, RNA
VLP (Virus Like Particles)	A61K20395258, C12N2770???23	VLP, virus like particles

APPENDIX E: PATENT STATUS DETERMINATION

DWPI database defines the status of a patent based on two factors: expiration date and terminal legal status events (failure to pay maintenance fees or revocation). Patents with no terminal events within their predicted term are categorised as not being 'Dead', patents with terminal events or that reach their expiration dates are categorised as 'Dead' and those without expiration and legal status data are categorised as 'Indeterminate'.[47]

The granted status of a patent application was determined using 'INPADOC Legal Status' and 'Publication Kind Code' details relating to that application available in DWPI database. If a patent was found to be 'Indeterminate', records from national offices were consulted, to the extent supported by the data quality, and these records were classified as 'Dead' or not 'Dead'. Families that remain 'Indeterminate' could not be adjusted in this manner, and may or may not be 'Dead'.

The logic for determining the granted status of a patent is as follows;

If not all family members are 'Dead' or 'Indeterminate' then:

- A patent family is 'Granted' if 'INPADOC Legal Status' /'Publication Kind Code' indicates that at least one family member was granted in any of the jurisdictions
- A patent family has protection 'Being sought' if there are no granted family members

If all family members are either 'Dead' or 'Indeterminate' then:

- A patent family is 'Indeterminate' if any family members are indeterminate
- A patent family is 'Dead' if all family members are dead

[47] Derwent Innovation Predictive Data Patent Status (Dead or Alive), https://clarivate.com/wp-content/uploads/2017/10/di_info_doa_en.pdf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