Europäisches Patentamt
European Patent Office
Office européen des brevets

50 years 1973 / 2023

mRNA technologies

Insight report

October 2023

epo.org

Executive summary

This report is the ninth patent insight report published by the European Patent Office (EPO), and the second report related to the medical sector.[1] Its objective is to provide an overview of important patent trends in the field of mRNA-based vaccines, which is a particularly dynamic sub-area of mRNA technologies.

The report summarises the results of patent analyses which were carried out jointly by subject-matter specialists and patent knowledge experts at the EPO. For this study, publicly available patent information drawn from the EPO's databases of worldwide patent data was analysed. Patent information constitutes a very rich source of technical information on inventions for which patent protection was sought based on the commercial expectations of the applicants. Patent information often includes technical and other information that is not available from any other source.

This report may be helpful as a source of information on mRNA-based vaccines. The methodology on which this report is based can be used freely, i.e. everyone can adapt the chosen search and analysis approach to their needs, for example to follow trends and developments in other established or emerging technical fields.

While the number of inventions in the field of mRNA-based vaccines is still rather low, it has increased very dynamically over the last decade at a rate which is significantly above the increase generally observed across all fields of technology combined. The figure on the next page shows the number of what are termed International Patent Families relating to mRNA-based vaccines and the number in all technical fields combined, by the year when the underlying inventions were made publicly available for the first time and could influence the activities of competitors and other researchers.

Patent applicants in the field of mRNA-based vaccines set a focus on the following patent application routes: International patent applications that may result in patent protection in more than 150 countries worldwide, US applications, EP applications, AU applications, CA applications, CN applications, and JP applications. The high proportion of International patent applications in the field of mRNA-based vaccines may be interpreted as an indication of the significant economic expectations of the patent applicants with regard to the technologies in question, as well as a corresponding multinational commercialisation strategy.

The EPO patent insight report on mRNA technologies in a nutshell:

- focus on mRNA-based vaccines
- number of inventions in the field of mRNA-based vaccines multiplied over the last decade
- higher growth rate than across all fields of technology in general
- upswing in filing numbers started in the 1990s
- high proportion of International patent applications, suggesting high economic expectations with regard to the technologies in question and multinational commercialisation strategy
- Most active applicants in the field of mRNA-based vaccines are companies and universities from the United States, Europe, and China.

The most active applicants in the field of mRNA-based vaccines are companies and universities based in the United States, Europe and China. The list of active applicants is headed by the companies Moderna and CureVac, which have submitted patent applications for a wide range of vaccines, whereas other active applicants have remained rather focussed on a specific target for vaccination, such as a particular pathogen or cancer.

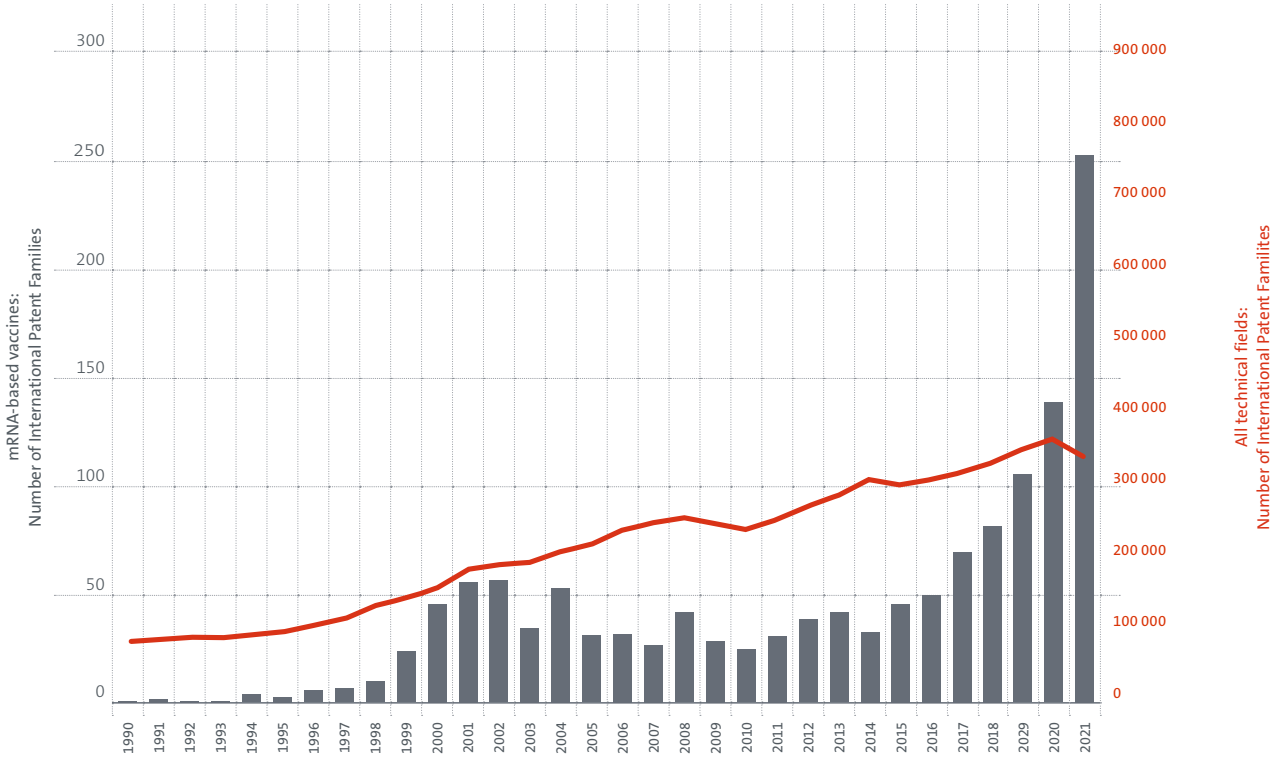
In view of the high momentum in the field of mRNA-based vaccines and the high number of exciting inventions in this area, the EPO intends to update this report in the future and extend it to encompass other relevant mRNA technologies as well.

1 More information about EPO patent insight reports and the list of currently available reports is available at epo.org/insight-reports

Figure 1

mRNA-based vaccines: Number of International Patent Families per earliest publication

Number of inventions by earliest publication year in the field of mRNA-based vaccines, limited to International Patent Families. International Patent Families group together patent documents relating to the same or similar inventions published by two or more patent authorities. It is generally assumed that patent applicants attribute greater economic potential to the underlying inventions of these patent families, and that they tend to seek more extensive commercialisation from a geographical point of view.



Source: authors' calculations

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Abbreviations

AU	Two-letter code used to label patent applications processed and published by IP Australia, an Australian goverment agency
CA	Two-letter code used to label patent applications processed and published by the Canadian Intellectual Property Office
CN	Two-letter code used to label patent applications processed and published by the China National Intellectual Property Administration
CPC	Cooperative Patent Classification
DE	Two-letter code used to label patent applications processed and published by the German Patent and Trade Mark Office
DNA	Deoxyribonucleic acid
DOCDB	EPO worldwide bibliographic data
EP	Two-letter code used to label patent applications processed and published by the European Patent Office
EPO	European Patent Office
EPC	European Patent Convention
GB	Two-letter code used to label patent applications processed and published by the Intellectual Property Office (United Kingdom)
IPC	International Patent Classification
JP	Two-letter code used to label patent applications processed and published by the Japan Patent Office
KR	Two-letter code used to label patent applications processed and published by the Korean Intellectual Property Office
LNP	Lipid-based nanoparticle
mRNA	Messenger ribonucleic acid
PCT	Patent Cooperation Treaty
RNA	Ribonucleic acid
tRNA	Transfer RNA
US	Two-letter code used to label patent applications processed and published by the United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WO	Two-letter code used to label patent applications processed and published by the World Intellectual Property Organization under the Patent Cooperation Treaty

Glossary

Cytoplasm	Content of eucaryotic cells inside the cell membrane except for the cell nucleus
Cytosol	Part of the cytoplasm
Enzyme	Protein acting as a catalyst
Espacenet	Free online patent searching service developed by the EPO. Includes information on more than 140 million documents from 100 patent offices. Espacenet is available at worldwide.espacenet.com.
Eucaryotic cell	Cells having a cell nucleus
International patent application	Patent application filed under the Patent Cooperation Treaty. An International patent application may result in patent protection in more than 150 countries.
International Patent Family	A patent family having patent family members published by at least two different patent authorities
Invention	A practical technical solution to a problem
in vitro	Outside the default biological context or environment
in vivo	Within the default biological context or environment
Jurisdiction	Country (territory) for which a patent or related intellectual property right may be granted by the corresponding intellectual property office.
Liposome	Spherical vesicle with liquid content enclosed by at least one lipid bilayer
Patent	Legal title giving the patent owner(s) the right to exclude others from using the protected invention in a commercial context. The invention is defined in the claims of the patent. The description and drawings provide additional information and are used to interpret the claims. The claims, description and drawings of a patent are together called the "patent specification".
Patent application	In the field of patent information, the expression "patent application" is used for both the patent application itself and the patent application published as a document.
Patent classification system	The set of patent classification symbols assigned to categorise the technical subject-matter of a patent or utility model. There are various patent classification systems used today by national, regional and international patent offices.
Patent family	A set of patent documents covering the same or similar technical content, depending on the patent family definition. The size of a patent family (family size) refers to the number of patent documents in that patent family. A DOCDB patent family is a set of patent documents relating to patent applications claiming priority of the same earlier applications. The technical content covered by the patent applications in a DOCDB patent family is considered to be identical.
Priority application	Inventions can be protected by patents and utility models in more than one country. For a period of 12 months from the date of filing an application for a patent in a member state of the Paris Convention, the applicant or their successor can claim a right of priority from that application for any subsequently filed patent application that concerns the same invention. If the requirements are fulfilled, the date of the earlier application counts as the date of filing of the later application for the purposes of examining novelty and inventive step.
Ribosome	Intracellular structure comprising ribosomal RNA and ribosomal proteins which binds mRNA and transfer RNA to perform protein synthesis

1. Introduction

1.1 About this report

This report is the ninth patent insight report published by the EPO.[2] The report provides an overview of technologies related to messenger ribonucleic acid (mRNA) delivered into human or other cells to trigger the production of specific functional proteins, with a focus on mRNA-based vaccines. mRNA-based vaccines have a wide range of applications, e.g. in the prevention and treatment of viral and bacterial infections, cancer and malaria, and contribute to the achievement of United Nations Sustainable Development Goal 3 (good health and well-being).[3]

Until recently, mRNA technologies were discussed by experts only. Lately, these technologies have received the attention of a wider audience due to the COVID-19 pandemic. Based on an impressive research effort, mRNA-based vaccines against SARS-CoV-2 were developed within a short time, and these vaccines made a key contribution to containing the pandemic. However, the rapid development of mRNA-based vaccines would not have been possible without extensive research into mRNA over the past decades (see Figure 2 for a timeline of milestones in the field of mRNA technologies).

The impressive momentum in the field of mRNA technologies can be seen not only in the wave of scientific and technical publications on this subject, but also in an upswing in the number of patent applications related to these technologies.

With this report, we would like to provide an overview of important patent trends in the field of mRNA-based vaccines. For this purpose, the report relies on publicly available patent information, which constitutes a very rich source of technical information on inventions for which patent protection was sought based on commercial expectations of the applicants. Patent information often includes technical information that is not available from any other source.

To gather relevant patent information as the basis for this report, search strategies were developed using meaningful keywords and relevant patent classification symbols. These search strategies, which are designed to strike a balance between completeness and a small fraction of unrelated documents in the result sets, were then used to create a basic dataset of relevant patent documents from the EPO's databases for worldwide patent data. This basic dataset formed the basis for the subsequent patent analyses.

This report may be helpful as a source of information on mRNA-based vaccines. The methodology on which this report is based can be used freely, i.e. everyone can adapt the chosen search and analysis approach to their needs, for example to follow trends and developments in other established or emerging technical fields.

2 More information about EPO patent insight reports and the list of currently available reports is available at epo.org/insight-reports.

3 See un.org/sustainabledevelopment/health

Figure 2

Selection of milestones in the development of mRNA technologies

Year	Structure and production of mRNA	Formulation of mRNA for delivery	mRNA-based drug applications e.g. mRNA vaccines	mRNA in gene editing
1961	Discovery of mRNA and its function	Protamine as an RNA carrier for in vitro uptake by eukaryotic cells		
1963			Induction of interferon by mRNA	
1969	In vitro translation of isolated mRNA in a cell-free system			
1974	Discovery of mRNA methylation			
1975	Discovery of mRNA 5'cap	First in vivo nucleic acid delivery by polymeric particles		
1978		Development of liposome-mRNA formulations		
1983	Cap analogue			
1984	In vitro mRNA synthesis (by SP6 RNA polymerase)			
1985	T7 RNA polymerase commercialised			
1989		Development of cationic lipid nanoparticle (LNP)-mRNA formulations Synthetic mRNA in cationic liposomes (structures made of positively-charged lipids) delivered to human cells, frog embryos		
1990			Free mRNA translation post intramuscular injection in mice Liposome-wrapped mRNA delivered to mice	
1992			Vasopressin mRNA injected to rat brain corrects disease	
1993			Development of liposome-mRNA influenza vaccine and tested in mice Discovery of induction of cellular immunity by mRNA	
1994	Development of self-amplifying mRNA			
1995			Discovery of induction of humoral immunity by mRNA First vaccination with mRNAs encoding cancer antigens: CEA mRNA cancer vaccine tested in mice	
1997	3'-UTR regulates mRNA localisation, stability and protein expression			
1999			In vivo induction of antitumor T-cell response by mRNA	
2001	Anti-reverse Cap analogue for superior translation efficiency and extended half-life		First clinical trial of mRNA-engineered dendritic cells	
2005	Nucleoside modification reduces the immunogenicity of mRNA			
2006	Poly(A) tail of 120 nucleosides and with free 3' end increases mRNA stability			
2008				Development of zinc finger mRNA for gene editing
2009			Clinical trial of mRNA therapeutics using protamine-mRNA formulations First human cancer immunotherapy using by injection of mRNA First adoptive immunotherapy with CAR mRNA	

Year	Structure and production of mRNA	Formulation of mRNA for delivery	mRNA-based drug applications e.g. mRNA vaccines	mRNA in gene editing
2010			Preclinical study with intra-nodally injected (dendritic cell-targeted) mRNA	
2011			Protein substitution preclinical studies: nucleoside-modified mRNA corrects disease	Development of transcription activator-like effector nuclease (TALEN) mRNA for gene editing
2012			Preclinical studies of influenza and RSV-specific mRNA combination vaccine	
2013	m6A modification increases mRNA stability		First clinical trial of mRNA vaccine for infectious disease	Development of CRISPR-Cas9 mRNA for gene editing
2014			Clinical trial of LNP-mRNA formulations for cancer immunotherapies	
2015	N1-methylpseudouridine enhances the expression and immune evasion of mRNA		First in-human test of personalised mRNA cancer vaccines Clinical trial of LNP-mRNA formulations as influenza vaccines Clinical trial of LNP-mRNA formulations for protein replacement therapies	
2017			First clinical trial of personalised mRNA-based cancer vaccine First report of mRNA LNP formulation of Zika virus vaccine in vivo	
2018	Sequence optimisation by uridine depletion increases mRNA activity			
2019			Clinical trials of mRNA vaccines for cancer and infectious diseases	
2020			Authorisation of 2 COVID-19 mRNA-based vaccines	Clinical trial of LNP formulations delivering gene-editing mRNA components for genetic disorders
2021		Adjuvant activity of LNPs in COVID-19 mRNA vaccines was identified		

Influential inventions in the field of mRNA-based vaccines:

Structure and production of mRNA	Formulation of mRNA for delivery	mRNA-based drug applications e.g. mRNA vaccines
EP2305699 Stabilised mRNA with increased G/C content which is optimised for translation in its coded areas for the vaccination against sleeping sickness, leishmaniosis and toxoplasmosis **EP1905844** Stabilised mRNA tumour vaccines **EP2578685** RNA containing modified nucleosides and methods of use thereof **EP3329941** RNA-coded bispecific antibody **EP2603590** Nucleic acid comprising or coding for a histone stem-loop and a poly(a) sequence or a polyadenylation signal for increasing the expression of an encoded protein **EP3134131** Nucleic acid vaccines	**EP1905844** Stabilised mRNA tumour vaccines **EP2590626** Liposomes with lipids having an advantageous PKA-value for RNA delivery **EP3623361** Lipids and lipid compositions for the delivery of active agents **EP3134131** Nucleic acid vaccines	**EP1905844** Stabilised mRNA tumour vaccines **EP3329941** RNA-coded bispecific antibody **EP2331129** Composition comprising a complexed (m)RNA and a naked mRNA for providing or enhancing an immunostimulatory response in a mammal and uses thereof **EP3134131** Nucleic acid vaccines

1.2 Introduction to mRNA technologies

mRNA is an indispensable molecule in the clockwork of human and other cells. In the cell, RNA is made from a DNA template during the process of transcription and mediates the transfer of genetic information from the cell nucleus to the cytoplasm where the information is translated into proteins by ribosomes and transfer RNA (tRNA). These proteins are of crucial importance in human and animal organisms, contributing to growth, maintenance and structure of tissues, to biochemical processes in the body as enzymes, to cell signalling and to the immune system, just to name a few examples.

mRNA technologies build on tailored mRNA to trigger cells to produce specific proteins which may be useful for a variety of medical applications. There is widespread agreement that we are just at the beginning of an era of efficient mRNA-based drugs to address a wide range of diseases, ranging from genetic diseases and various kinds of cancer to infectious diseases.

mRNA structure and synthesis

From a biochemical point of view, mRNA is essentially a specific representation of genetic information based on four nucleotides (adenine, guanine, cytosine and uracil).

mRNA is synthesised in the cell nucleus during transcription to produce pre-mRNA followed by processing to mRNA. During transcription, the genetic information is copied from DNA by RNA polymerases, forming the so-called pre-mRNA. This molecule is then processed by the addition of a 5' cap and a 3' poly(A) tail, and by splicing out intron sequences in the nucleus to form the five-component mature mRNA structure. Each component within the mRNA structure has a specific role in the transportation, translation and efficient production of proteins by the ribosomes in the cytoplasm (see Figure 3).

Historical development

The isolation of mRNA and its role in protein synthesis was described in reference literature in 1961 for the first time, building on elaborate work that started in the 1950s. It took another fifteen years before researchers could show that mRNA can be delivered into human cells by encapsulation in non-inflammatory polymers. Shortly after, in 1978, it was demonstrated that mRNA molecules can be delivered to human and animal cells by using liposomes.

Elaborate research on optimising the mRNA structure and delivery systems conducted by numerous scientists led to further breakthroughs in the medical use of mRNA, such as the first use of mRNA in a cancer vaccine (1995)

Figure 3

Structure of a typical human mRNA molecule

5' cap: A sub-structure in the mRNA molecule which protects the molecule from decomposition by specific enzymes. It plays a fundamental role in putting the mRNA molecule in a position to be read in the ribosome and to have the genetic information translated during protein synthesis. The 5' cap remains untranslated during the protein synthesis.

5' untranslated region (5' UTR): Sub-structure in the mRNA which precedes the coding region and remains untranslated in most cases during protein synthesis in the ribosome. It plays an important role in regulating the process of translating genetic information into the protein. It also supports the ribosome in recognising the mRNA molecule and helps to modify the mRNA after the translation process is completed.

Coding region: Sub-structure that contains a representation of the genetic information for the production of a protein.

3' untranslated region (3' UTR): Sub-structure which follows the coding region and generally remains untranslated during protein synthesis in the ribosome. It has several regulatory functions for the copying of the genetic information in the cell nucleus, the transportation of the mRNA molecule from the cell nucleus to the ribosome and for the regulation of the translation of genetic information during protein synthesis.

Poly(A) tail: This part of the mRNA molecule is important for the export of the molecule from the cell nucleus, for the translation process and for the stability of the mRNA molecule. It also protects the mRNA molecule from degradation and has an important effect on the lifespan of the molecule: the poly(A) tail is gradually shortened over time and, below a certain threshold, the molecule may be degraded enzymatically.

and the first clinical trial of a personalised mRNA-based cancer vaccine (2017). The COVID-19 pandemic substantially accelerated research and development regarding mRNA technologies and led to a breakthrough for mRNA-based vaccines. Today, research and development is mainly directed at the following medical applications of mRNA: vaccines for disease prevention and therapeutic applications, and therapeutics, e.g. by protein replacement.

Challenges

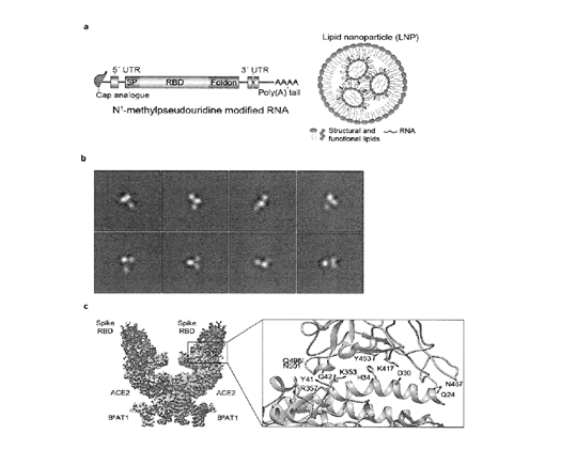
Despite the impressive progress made in recent decades regarding the role of mRNA in the synthesis of proteins in human and animal cells and the application of mRNA in medicine, there is still extensive need for better understanding of the biochemical processes involved in the synthesis of mRNA, its transport and translation into proteins. At the same time, there is widespread agreement that we are just at the beginning of an era of development of efficient mRNA-based drugs to address a variety of diseases, including genetic diseases, cancers and infectious diseases.

The medical use of mRNA to treat and prevent diseases requires production of functional mRNA in sufficient quantities which are translated successfully into active proteins. Additionally, the mRNA for medical use should be safe without serious side effects and unwanted immune reactions.

To this end, it will be necessary to further address a number of obstacles and opportunities for improvement, including the following examples.

Topic	Technical aspect	Objective
mRNA design and synthesis	**Stability**	mRNA is highly unstable The structure of the molecule has an impact on its stability. Tailoring the mRNA structure will improve the stability of the molecule, e.g. by optimising non-coding sequences and by other chemical modifications.
	Purification	mRNA molecules for therapeutic and preventive medical applications are generally synthesised in vitro in cell-free systems. The as-synthesised molecules need to be purified using conventional laboratory methods. Advanced purification methods will help to improve the removal of impurities such as RNA fragments and double-stranded RNA, which may give rise to unwanted effects and reduce the therapeutic or prevention efficacy.
Delivery	**Stability**	mRNA molecules must cross the cell membrane to reach the cytosol. This is challenging due to the negative charge, the relatively large size and the degradability of mRNA. The mRNA delivery system has a crucial impact on the efficiency. The development of mRNA-based vaccines and therapeutics has clearly profited from the development of delivery systems such as lipid-based and polymer-based nanoparticles. These nanoparticles protect the unstable mRNA molecule against degradation and promote its internalisation in order to initiate protein synthesis. Advanced drug delivery systems will not only reduce mRNA degradation and promote mRNA delivery to cells, but also enable targeting of mRNA to specific cells. This will allow the medical application of mRNA-based vaccination and (targeted) therapies to be broadened.

Box 1: Example of inventions related to mRNA-based vaccines



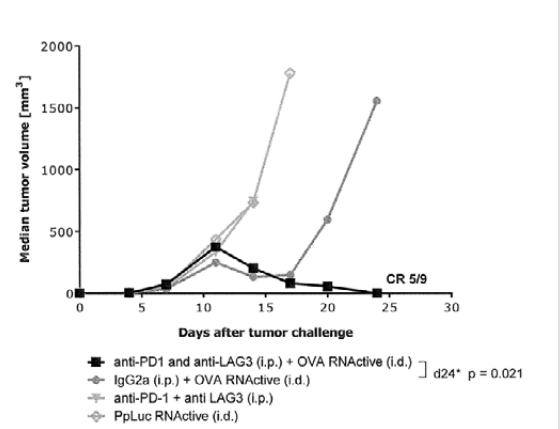
WO2021213924A1

Coronavirus vaccine

This patent application relates to using mRNA to induce an immune response in humans against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), such as antibody and T cell response. In particular, the invention relates to an mRNA-based vaccine coding for the receptor-binding domain of the SARS-CoV-2 Spike protein.

The patent application presents various embodiments of the invention. The RNA of the invention is a modified RNA, with substitutions of some or all uridine residues by modified uridine. The RNA is formulated in lipid nanoparticles comprising different lipids.

Apart from providing detailed technical information on the invention, the patent application discloses experimental data on clinical trials related to the claimed vaccines, as well as information on tests and safety evaluations.



WO2018167320

RNA vaccine and immune checkpoint inhibitors for combined anticancer therapy

This patent application relates to a combination of an mRNA-based vaccine comprising an open reading frame which encodes an antigen, a PD-1 pathway inhibitor, and a LAG-3 pathway inhibitor. The mRNA molecule has a GC-optimized sequence, a 3'UTR and a poly(A)-sequence, a poly(C)-sequence and a histone stem loop.

The patent application shows that the combination of two immune checkpoint inhibitors with the mRNA vaccine induces significantly enhanced anti-tumour response of the mRNA-based vaccine. The application combines two very popular and effective immunotherapies.

mRNA-based vaccines

mRNA vaccines have come under the spotlight during the COVID-19 pandemic as a technology used by many companies to develop vaccines. However, the potential of mRNA therapy and specifically mRNA vaccines had already been hinted at long before with the in vivo expression of a protein after injecting the coding mRNA into mouse skeletal muscle in 1990, and with the demonstration of the induction of a cellular and humoral immune response by a liposome encapsulated mRNA vaccine in 1993 and 1995.

mRNA technology presents several advantages that makes it an attractive alternative over traditional vaccines. Unlike attenuated or inactivated vaccines, mRNA is precise, as it will only express a specific antigen and induce a directed immune response. Additionally, it promotes both humoral and cellular immune response while also inducing the innate immune system, which is an advantage over many protein/peptide vaccines, and results in an improved protective effect.

mRNA vaccines also have advantages over DNA-based vaccines: mRNA is more effective, since antigen expression does not require nuclear entry, and safer, since there is no danger of integration into the genome. The in vivo expression of the coded antigens is temporary since mRNA is degraded by cellular processes within a few days. Another advantage of mRNA-based vaccines is its relatively simple manufacturing: mRNA is produced in a cell-free system and relies on an RNA polymerase to catalyse the synthesis of the target mRNA from the corresponding DNA template. As demonstrated during the COVID-19 pandemic, the mRNA vaccine platform is flexible for quick adaption to antigen variants, which is a huge advantage for mRNA vaccine production.

Over the years, the efficacy of mRNA vaccines has been demonstrated in treatment of cancer and prevention of viral, bacterial and malaria infections, and many mRNA vaccines are now tested in clinical trials.

Not surprisingly, mRNA-based vaccine technology also faces challenges: (i) the low stability of mRNA which has implications on storage conditions, (ii) the highly negative charge of mRNA and its large size make it difficult to enter the cell and (iii) the induction of an unwanted immune response as a side effect. Further research has led to improved mRNA stability and less unwanted immune responses by incorporating modified nucleosides, 5' cap and a longer poly(A) tail. Challenges impeding of mRNA entry into the cell have been addressed by developing mRNA carriers like liposomes, lipid nanoparticles, lipoplexes, polyplexes and polymeric nanoparticles.

Box 2: European patent system and inventions in the field of vaccines

The European patent system makes it possible to obtain European patents valid in up to 39 Contracting States to the European Patent Convention (EPC) on the basis of a single application.[1] A European patent has the same legal effects as a national patent in each country for which it is granted. As of 2023, it is also possible to request unitary effect for a granted European patent. This currently provides uniform patent protection in 17 Member States of the European Union, and the scope will be even broader once more Member States join the unitary patent system in the future.

European patents are granted by the European Patent Office in a centralised, cost-effective and time-saving procedure conducted in English, French or German. Every patent application undergoes substantive examination before a European patent is granted to make sure that inventions for which patent protection is sought meet all legal requirements set out in the EPC. Patents are granted for inventions across all fields of technology if they are new, involve an inventive step and are industrially applicable. An invention meets these requirements if it was not known to the public in any form prior to the filing or, if claimed, priority date, was not obvious to a "person skilled in the art", i.e. an average specialist in the relevant technical field, and can be manufactured or used industrially. Inventions in the field of vaccines, including mRNA-based vaccines, are no exception to this.

The claims in a patent application define the subject matter for which protection is sought. Subject matter defined in the claims may relate to e.g. products, processes, apparatuses or uses. Patent claims must be clear and concise. They should not use terms and expressions which would leave doubt as to their scope. The claims must contain all technical features necessary to produce the claimed technical effect.

Apart from the clarity requirement, the invention must be disclosed in the application in a way that a person skilled in the art is able to carry it out without undue burden. For this purpose, the applicant needs to file experimental evidence, e.g. to support any claimed therapeutic/protective effect of the vaccine. The amount and nature of the experimental data should be aligned with the subject matter for which protection is sought, and will differ depending on the claimed invention.

More information relevant for the assessment of inventions related to vaccines under the EPC is available in the Guidelines for Examination in the European Patent Office[2] and in the Case Law of the Boards of Appeal.[3]

1 European patents may also be effective in some countries that have not acceded to the EPC extension and validation states).

2 See epo.org/law-practice/legal-texts/guidelines.html, in particular Section F-IV.

3 See in particular the following cases: T 0187/93 and T 0219/01 relating to the sufficiency of disclosure according to Art. 83 and Art. 84 EPC, and T 0893/02 relating to the inventive step requirement according to Art. 56 EPC.

Further reading

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2. Methodology and sources of patent information used

2.1 Using patent information

In essence, patents are legal rights which confer on patent holders the right to exclude others from commercially using the patented invention. They can be valid in the country or region for which they were granted. Patents can help to attract investment, secure licensing deals and provide market exclusivity.

With that, patent systems foster innovation, technology diffusion and economic growth by allowing patent holders to secure investments in research and development, education and infrastructure while requiring them to disclose their inventions to the public in return. To this end, patent information is at the core of any patent system.

Patent information enables others to build on the published inventions of other inventors and also to avoid the mistake of investing in developing a solution for a problem that has already been solved by others and is potentially protected. Patent information contains a wealth of technical and other information, much of which cannot be found in any other source.

The EPO alone, as the leading provider of high-quality patent information worldwide, has collected, standardised and harmonised information on more than 140 million patent documents from more than 100 countries in its databases, amounting to more than one billion records. These databases continue to grow by tens of millions of records every year.

Patent information from these databases is available via numerous free and commercial patent information services provided by patent offices and service providers worldwide. The information may be used for various analyses, e.g. to explore technical trends and the filing strategies of applicants, or to calculate indicators of innovation activity, commercialisation and knowledge transfer.

2.2 Methodology for this EPO patent insight report

This EPO patent insight report is designed to provide useful insights into the field of mRNA-based vaccines as an important and particularly dynamic sub-area of mRNA technologies (see figure 4 for a cartography of sub-areas of these technologies which we used for this report).

The report is based on publicly available patent information and acts as a snapshot of the technologies, taken in the light of patent information.

The methodology of this report is based on a three-step process:

Step 1: Creating and tuning a basic data set

A basic dataset is created, usually based on various individual search concepts, e.g. building on keywords and on patent classification symbols for specific technologies.

Typically, unrelated patent documents will have to be removed from the resulting dataset in an automated or manual manner to increase the quality of the basic dataset

The creation of a meaningful basic dataset is critical to providing a reliable basis for sound patent analysis in Step 2.

Step 2: Patent analytics

In this second step, analyses are performed on the basic dataset, e.g. by aggregating the data to patent families as a representative of inventions, creating descriptive statistics, testing hypotheses, and recognising patterns in the data.

Step 3: Further processing and visualisation

In this third step, the data are further analysed and processed. Results are visualised and summarised.

The methodology underlying this report and the details are free to use. As a result, anyone can apply the proposed analytical approach to reveal trends and prospects in the same or other areas of technology, and adapt the approach to their own needs.

2.3 Patent retrieval

For this report, EPO subject-matter experts developed dedicated search strategies to identify patent documents that relate to mRNA-based vaccines. The search strategies combine relevant keywords and patent classification symbols (see Box 3). The search strategies were optimised for the EPO's in-house search tools (see Section 2.3.1).

The patent classification symbols and keywords used for this report efficiently capture documents with a focus on mRNA-based vaccines, as opposed to, for example, more general technical improvements that may be useful in the field of mRNA-based vaccines as well as in other technical domains, and thus extend beyond that specific field.[4]

The volume of search results retrieved using the search methodology will grow over time due to the dynamic nature of the technical field and of the patent databases, as patent documents relating to mRNA-based vaccines are continuously being added to these databases. Accordingly, we intend to update this report in the future, which would also give an opportunity to produce an analysis of patent trends regarding specific other aspects of mRNA technologies.

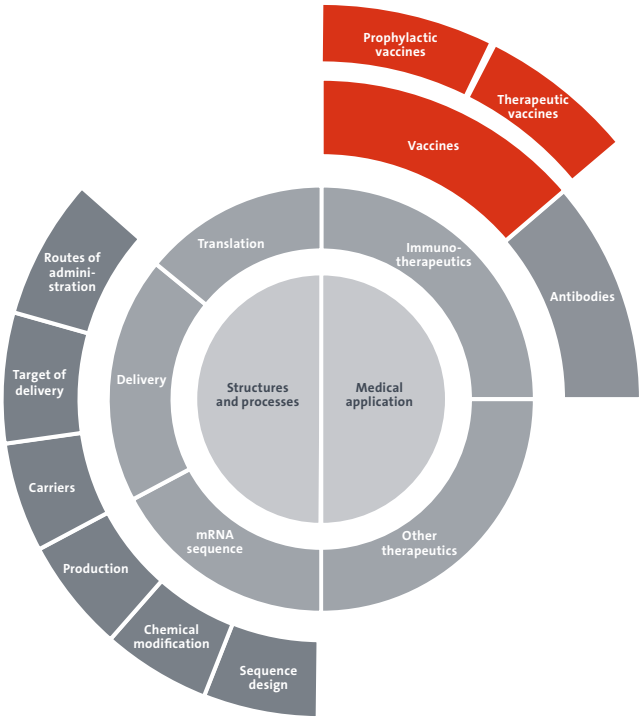
The dedicated seach strategies developed for this report will be made available as part of the supplementary materials which accompany it. The search strategies may be translated into search statements for other patent search tools that are publicly available on the internet, such as the EPO's search interface Espacenet.[5]

4 See e.g. M. Gaviria and B. Kilic, A network analysis of COVID-19 mRNA vaccine patents, Nature Biotechnology 39, 2021, 546–549 and M. Li et al., The global mRNA vaccine patent landscape, Human Vaccines & Immunotherapeutics, 18, 2022, Art. No. e2095837 for patent analyses on the same subject with alternative methodologies and focus of the analyses.

5 Available at worldwide.espacenet.com.

Figure 4

A cartography of mRNA technologies used for this report. The sub-area of mRNA technologies related to vaccines (highlighted in red) was the focus of this publication.



Box 3: mRNA-based vaccines and patent classification schemes

Patent offices assign patent classification symbols to categorise the technical subject matter of a patent or utility model. Patent classification symbols are defined as part of what are known as "patent classification systems". There are various patent classification systems used today by national, regional and international patent offices.

Two patent classification systems are of particular importance.

The **International Patent Classification (IPC)** system is a hierarchical patent classification system which is used by more than 100 patent offices on all continents, including the EPO. It breaks technologies down into eight sections with several hierarchical sub-levels. The IPC system has approximately 75 000 subdivisions and is updated on an annual basis. Further information about the IPC system is available at a dedicated website.

The **Cooperative Patent Classification (CPC)** system builds on the IPC system and provides a more granular and detailed classification structure. The CPC system has more than 250 000 sub-divisions and is updated four times a year. It is used by more than 30 patent offices worldwide, including the EPO. Further information about the CPC system is available on the CPC website.

IPC and CPC classification symbols can be used to quickly retrieve relevant patent documents using search interfaces such as the EPO's free search interface Espacenet, for example.

For the purposes of this study, sub-divisions in the IPC and the CPC systems were used and combined with other search terms to restrict the resulting dataset to patent documents closely related to mRNA vaccines. The following table shows a selection of the IPC and CPC sub-divisions used:

Sub-division	Description
A61K39/0011	Cancer antigens
A61K39/015	Hemosporidia antigens
A61K39/02	Bacterial antigens
A61K39/12	Viral antigens
A61K2039/53	DNA/RNA vaccination
C12N2710/00	dsDNA viruses
C12N2730/00	Reverse transcribing DNA viruses
C12N2740/00	Reverse transcribing RNA
C12N2760/00	ssRNA viruses negative-sense
C12N2770/00	ssRNA viruses positive-sense

2.3.1 Data sources and tools used

The quality of the patent data analysis largely depends on the completeness, correctness and timely availability of relevant patent information in the patent databases from which the basic dataset for the subsequent analysis is extracted.

Absolute completeness of the relevant patent information is not possible as not all data are available from all patent offices.

However, there are several patent databases that have very good or excellent coverage of patent information from the main patent offices. These patent databases mostly rely on EPO worldwide patent data as a central source of prior art patent information.

EPO worldwide patent data include bibliographic and other information on more than 140 million patent documents from more than 100 patent authorities on all continents. These data are available via the EPO patent information products and services,[6] and via other major free and commercial search interfaces for patent information.

For this EPO patent insight report, patent searches were carried out using EPO worldwide patent data via the EPO's internal data platforms and search interfaces such as ANSERA[7] to create the basic dataset for subsequent patent analyses.

The resulting basic dataset was combined with added value data contained in the EPO's PATSTAT product line,[8] which provided the advanced basis for the patent data analysis step and was used for further processing and visualisation of the data.

6 More information is available at epo.org/searching-for-patents.html.

7 See Y.Tang Demey and D. Golzio, Search strategies at the European Patent Office, World Patent Information 63, 2020.

8 The Spring 2023 edition of the PATSTAT product line was used for this report.

3. Analysis

This section presents the results of the analyses regarding the field of mRNA-based vaccines. For this purpose, filing trends in that field are first considered and then the findings are compared with the overall situation across all fields of technology. Then, the main jurisdictions for which protection was sought are looked at. This section ends with an analysis of active applicants in the field of mRNA-based vaccines and their thematic focus.

The number of patent applications in the field of mRNA-based vaccines has increased very dynamically in recent years. More than 2 300 inventions related to these vaccines were identified during the analysis. Figure 5 shows the number of inventions, approximated by DOCDB simple patent families[9] in the field of mRNA-based vaccines by the earliest publication date. This date was chosen to represent the moment when the invention was first available to the public and could stimulate research activities by others and influence the commercial strategy of competitors. In this case, the earliest publication date is of fundamental importance for the technical and economic development of a technical field.

The figure shows a steep increase in the number of inventions over the past decade. This increase exceeds the generally observed rate of increase in the number of inventions across all fields of technology combined (see the red scale at right in Figure 5).

Figure 5 also reflects the development of mRNA technologies. While the research into mRNA-related matters started several decades ago, it took some time – in light of the complexity of the topic and the challenges involved – to advance the know-how and the techniques to a level that allowed the commercialisation of mRNA technologies (see also the timeline in Figure 2). With the successes in formulations for RNA delivery and in mRNA-based drug development at the end of the 1980s and during the 1990s, it was just a matter of time before actual mRNA-based vaccines became realistic. Correspondingly, steps were taken by active parties in that field to secure their investments and inventions by means of patent protection, resulting in a first upswing in the number of patent applications in the 1990s.

Figure 5 takes into account patent families with patent applications which have been filed in a single national jurisdiction as well as in multiple jurisdictions. For the latter grouping of patent families, it is generally assumed that patent applicants attribute greater economic potential to the underlying inventions, and that they tend to seek more extensive commercialisation from a geographical point of view.[10]

Accordingly, we have focused our analysis on this category of patent families, which are generally referred to as International Patent Families. When plotting the number of International Patent Families for mRNA-based vaccines as a function of the earliest publication year, the dynamics described earlier become even more apparent.

More than 1 800 International Patent Families were identified in the field of mRNA-based vaccines. While the number of inventions for all fields of technology is continuously increasing, the increase in the field of mRNA-based vaccines is far above average (Figure 6). Furthermore, no indications have been found during our analysis that this development will lose momentum in the next few years.

Patent family members in these International Patent Families are not evenly distributed across all patent authorities. Figure 7 shows that patent applicants set a strong focus on the following patent application routes: international applications[11], US applications, EP applications, AU applications, CA applications, CN applications, and JP applications.

9 A DOCDB simple patent family is essentially a set of patent documents relating to patent applications claiming priority from the same earlier applications. The technical content covered by the patent applications in a DOCDB simple patent family is considered to be identical.

10 In this context, the centralised application and granting procedure under the European Patent Convention may lead to patent applicants and inventions with an exclusive focus on Europe being underrepresented in the report. By default, patent applications using the European route, and the patents granted, are only published as EP documents although these patents may be valid in more than one country and, accordingly, reflect a multinational strategy. This means that inventions for which protection was exclusively sought using the European procedure may not be mapped as International Patent Families in the analyses despite the multinational filing strategy behind them.

11 I.e. patent applications filed under the Patent Cooperation Treaty (PCT). Correspondingly, these patent applications are often referred to as PCT or International patent applications. See wipo.int/pct/en for more information.

In Figure 8, the percentages of these patent application routes for mRNA-based vaccines in terms of all patent application routes are presented. In this technical field, the PCT application route has been playing a continuously important role over the past decades. This is in contrast to the situation in all technical fields where the fraction of PCT applications was still at a rather low level in the 1990s and has continuously increased since then, whereas it generally remains below the level of mRNA-based vaccines (Figure 9). The continuously important role of PCT applications for inventions related to mRNA-based vaccines may be interpreted as an indication of the high economic expectations of the patent applicants with regard to mRNA-based vaccines, as well as a corresponding consistent multinational commercialisation strategy.

One important indicator of the strategic orientation and success of patent filing strategies in the field of mRNA-based vaccines is the proportion of granted IP rights in a specific country or region. Figure 10 shows the proportion of International Patent Families in that field for which at least one IP right was granted in a specific jurisdiction. For more than 35% of these International Patent Families, at least one IP right was granted for the United States, underlining its important role in the field of mRNA-based vaccines. For other legislations, the proportion is also substantial but lower than in the United States. Examples of important markets include Europe (23%, based on EP patents), Australia (21%), Japan (16%), Canada (11%), and China (9%).

EP applications are a special case. The European Patent Convention (EPC) has established a single application procedure for obtaining patent protection in Europe. With just one patent application, applicants can protect their invention not only in all of the 39 Contracting States that have acceded to the EPC, but also in one extension state and four validation states. [12]

Figure 11 shows the percentage of EP patents in International Patent Families in the field of mRNA-based vaccines that were validated and maintained in an EPC Contracting State, extension state or validation state (red). The figure provides an indication of the importance of a country as a location for research and production, and as a market in the field of mRNA-based vaccines, according to patent holders in that field. [13] For comparison, the percentage of EP patents in International Patent Families in all technical fields combined are shown, too (black).

While EP patents are typically maintained in countries representing the biggest markets (including DE, FR and GB) in all technical fields combined, the situation is different for mRNA-based vaccines where EP patents are validated and maintained in a considerably larger number of countries on average. This may be an indication that the potential markets have an above-average influence on the IP strategy of the applicants in the field of mRNA-based vaccines.

The analysis also looked at active patent applicants in the field of mRNA-based vaccines. For this purpose, patent applicant data were consolidated in the basic dataset for this report by aggregating patent applicants belonging to the same corporate tree. Individuals jointly listed with legal entities as patent applicants were also aggregated with these. [14] The most active applicants in the field are companies and universities. Most of them are located in the United States, Europe or China (Table 1). The list of most active applicants in the field is headed by Moderna and CureVac.

The picture becomes more nuanced when looking at the development in recent decades in greater detail (see Table 2). During this period, the percentage of universities and non-profit organisations has been high, notably in the United States and Germany. In many cases, patent applications from these entities were co-submitted with other university and non-profit organisations but also with companies, which may reflect active collaboration, investment relationships or contractual obligations.

To shed more light on the extent of co-applications between applicants from industry, universities and non-profit organisations, we analysed International Patent Families in the field of mRNA-based vaccines with patent applications filed by applicants from more than one entity.

12 See epo.org/applying/european.html for more information about the European patent application route.
13 This figure is based on procedural information related to the payment of maintenance fees for EP patents in these countries, as available via the EPO worldwide legal event data (INPADOC) service
14 The corporate tree covers the subsidiaries and companies (legal entities) in a holding structure.

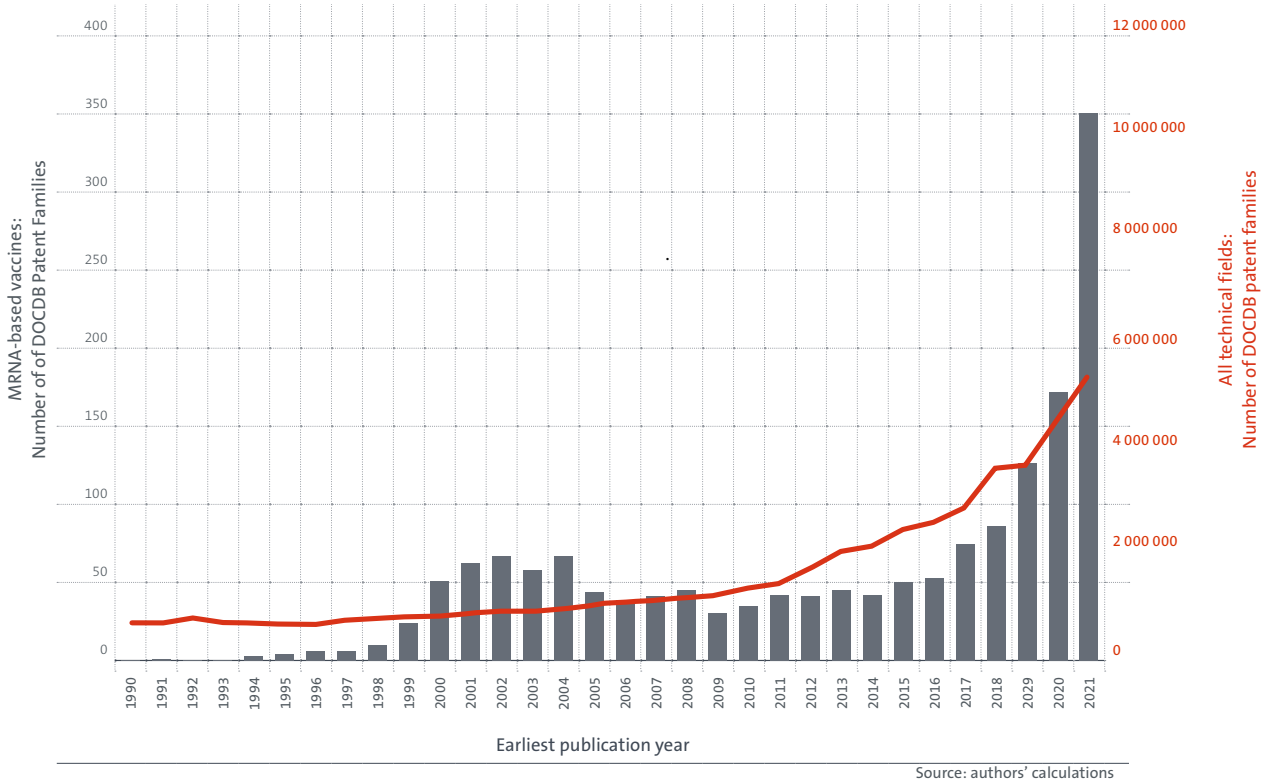
Table 3 presents a list of patent applicants who have actively filed patent applications with other entities. As in other emerging technologies, we found a wide range of co-application patterns among the active applicants. A prominent example is Biontech, which is among the most active applicants in the field of mRNA-based vaccines and heads the list of applicants with a propensity to joint patent applications. In about 70 percent of its International Patent Families in the field of mRNA-based vaccines, Biontech co-applied with patent applicants from another entity. In most of these cases, the company co-applied with the University of Mainz, followed by companies such as Genentech, Astellas Pharma or Pfizer, reflecting the elaborate collaboration and commercialisation strategy of the company.

We also looked at the thematic focus of applicants in the field of mRNA-based vaccines to better understand their research and commercial priorities in recent decades. Figure 12 shows the number of International Patent Families for important groups of vaccines (anti-cancer vaccines, anti-viral vaccines, anti-bacterial vaccines and anti-malaria vaccines) per earliest publication year. In the 1990s, at the early stages of commercialisation of mRNA-based vaccines, only a minority of inventions were found to address specific groups of vaccines. With continued technical development and commercial readiness, the percentage of inventions with a specific focus in line with said groups of vaccines has grown notably, with a high percentage of International Patent Families addressing anti-viral and anti-cancer vaccines in recent years (Figure 12, bottom).

The heat map in Figure 13 displays the number of International Patent Families of active applicants in the field of mRNA-based vaccines, broken down into specific vaccines belonging in the four groups of vaccines noted above. High numbers of International Patent families are shown in differing shades of red, while low numbers are shown in blue. In the heat map, the thematic focus of the active applicants becomes visible. Only few active applicants, such as Moderna and CureVac, have submitted patent applications for a wide range of vaccine targets, whereas other applicants have remained either quite focussed or unspecific in terms of their respective vaccine targets.

Figure 5

Number of DOCDB patent families per earliest publication year related to mRNA-based vaccines

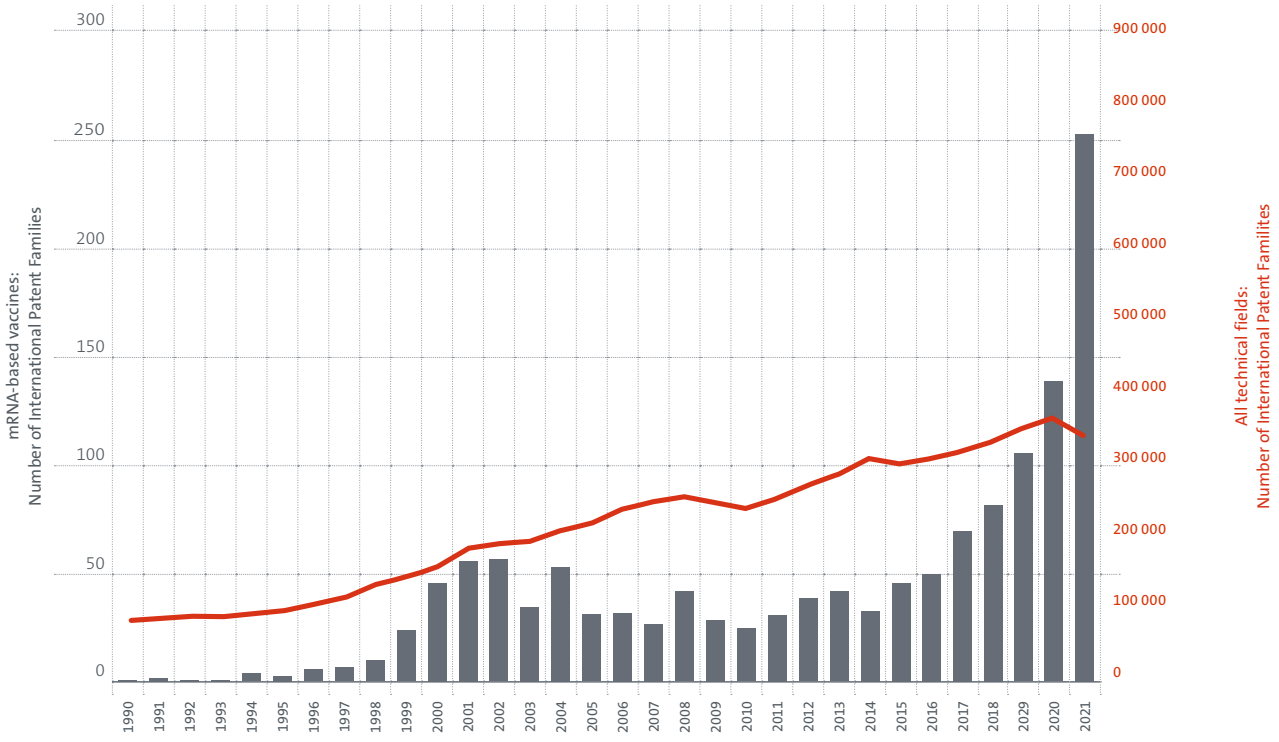


Source: authors' calculations

Figure 6

mRNA-based vaccines: Number of International Patent Families per earliest publication

Number of inventions by earliest publication year in the field of mRNA-based vaccines, limited to International Patent Families. International Patent Families group together patent documents relating to the same or similar inventions published by two or more patent authorities. It is generally assumed that patent applicants attribute greater economic potential to the underlying inventions of these patent families, and that they tend to seek more extensive commercialisation from a geographical point of view.

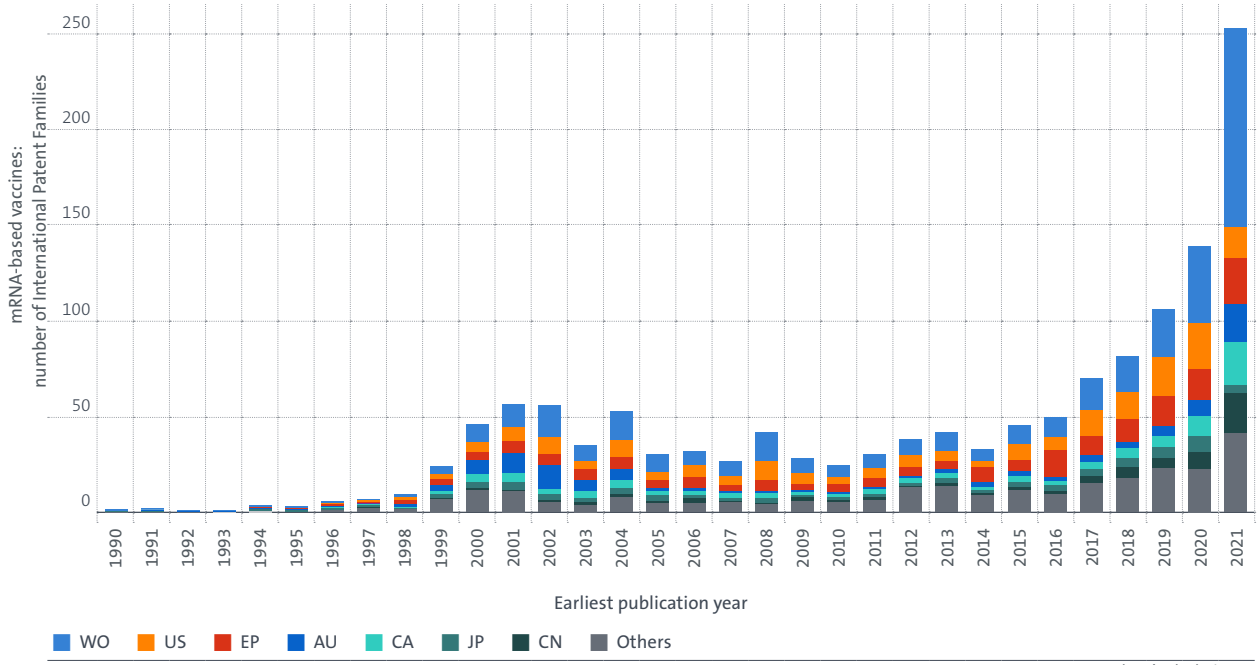


Source: authors' calculations

Figure 7

Breakdown of filing statistics in the field of mRNA-based vaccines as to publishing patent authorities, per earliest publication year

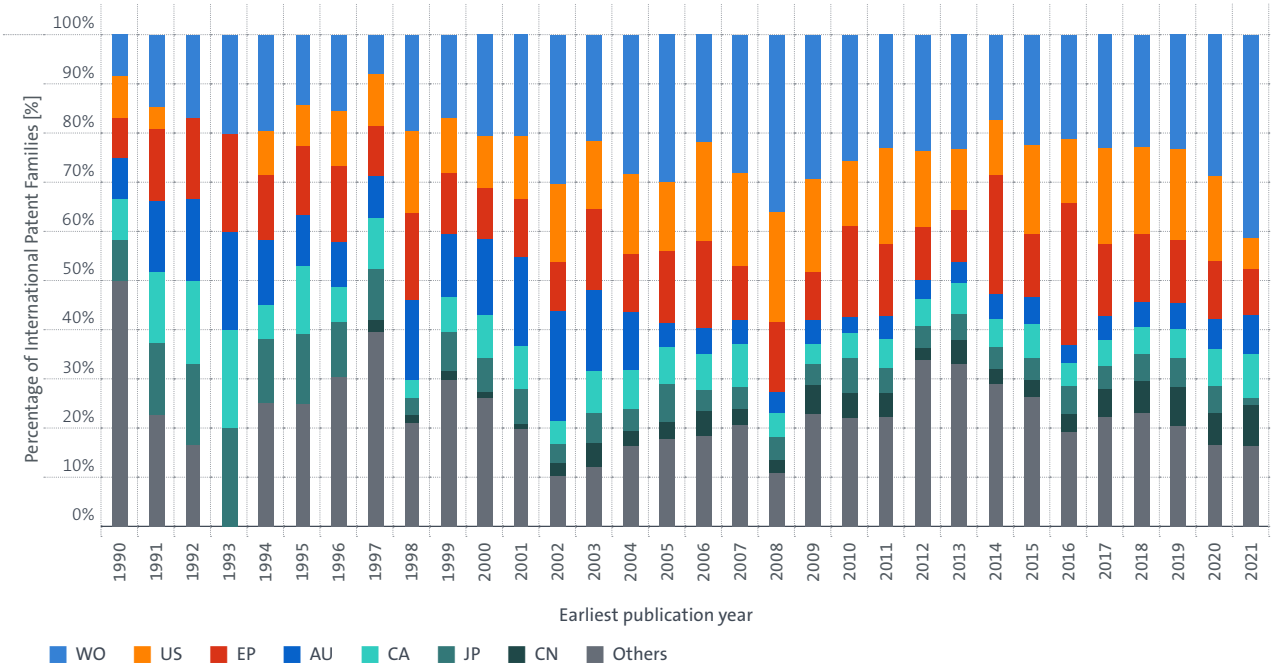
Fractional counting according to patent authority was used. For each patent authority, only one patent publication in the patent family was counted, which helps to avoid double counting and over-representing the patent authority.



Source: authors' calculations

Figure 8

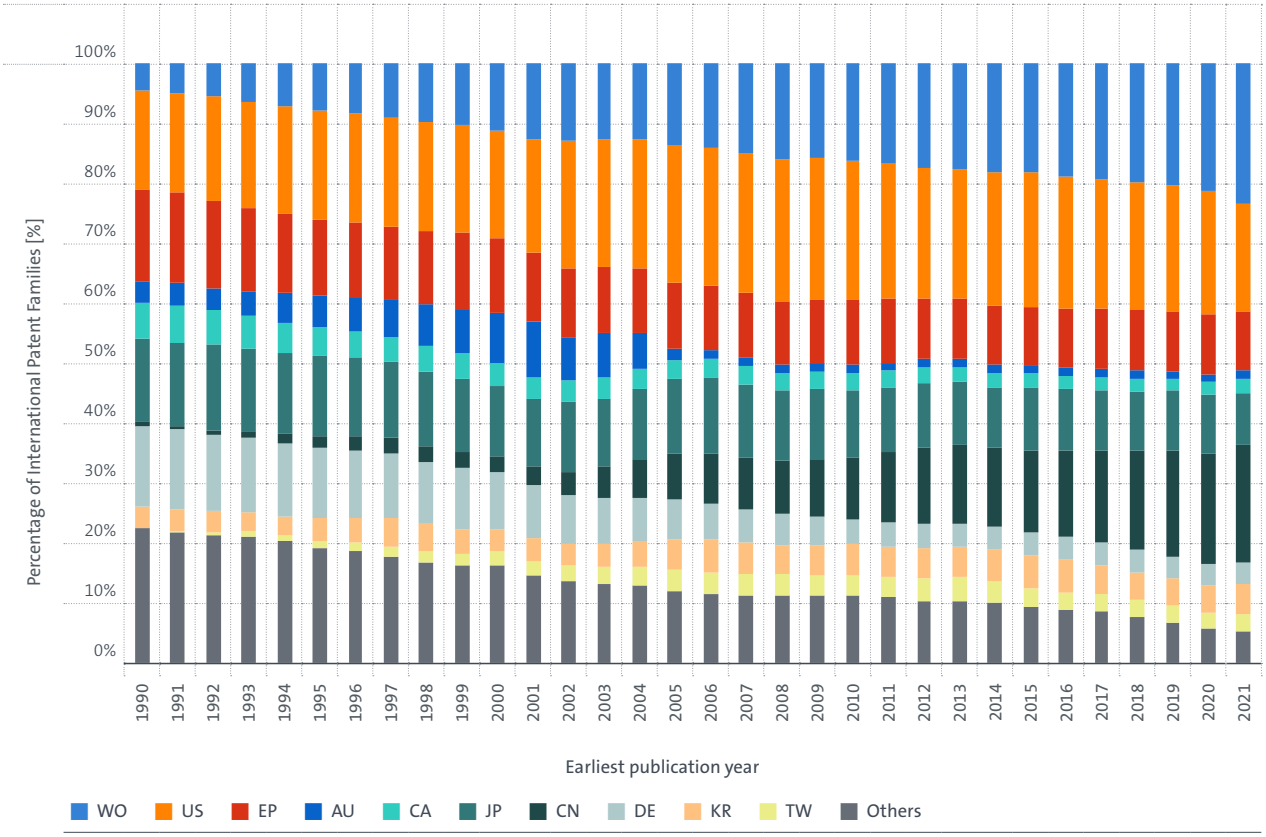
Breakdown of filing statistics in the field of mRNA-based vaccines according to publishing authority, per earliest publication year



Source: authors' calculations

Figure 9

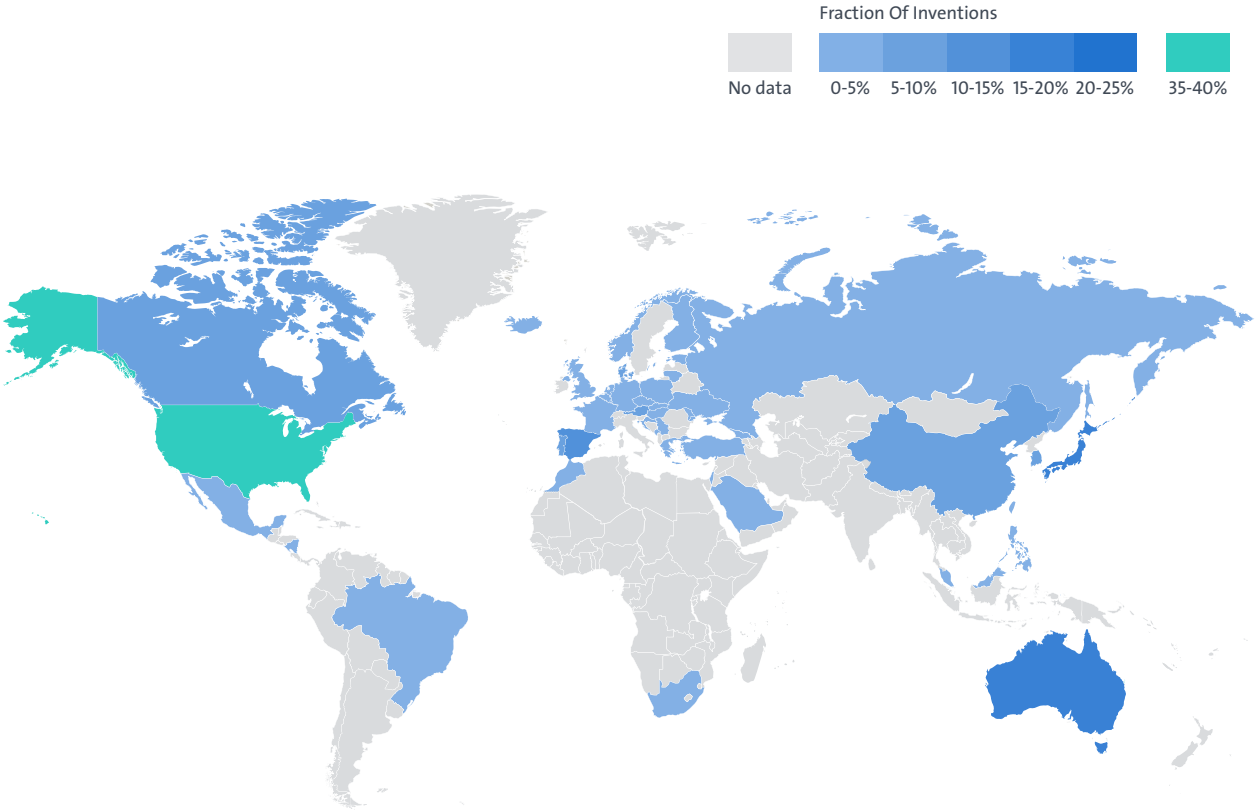
Breakdown of filing statistics in all technical fields according to publishing authority, per earliest publication year



Source: authors' calculations

Figure 10

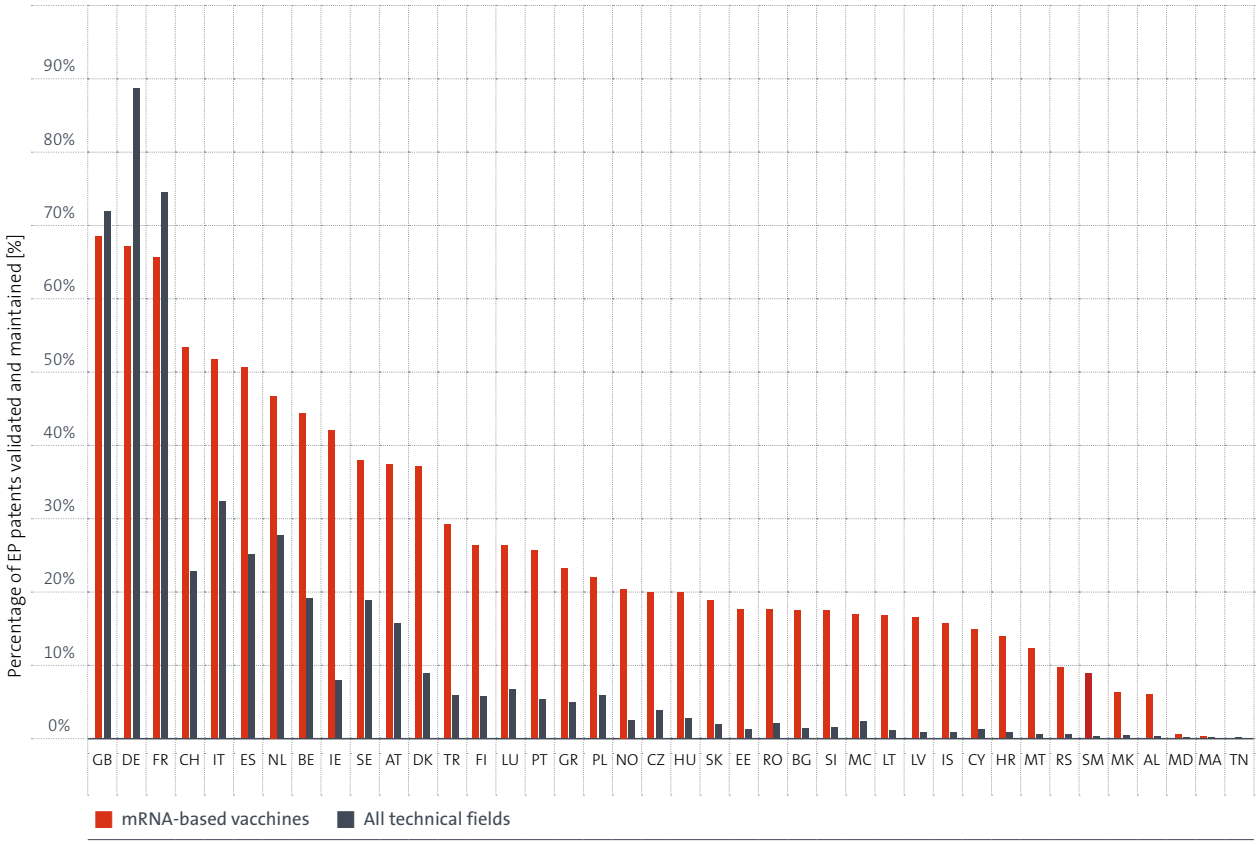
Proportion of International Patent Families in the field of mRNA-based vaccines for which at least one patent or utility model was granted or registered in a specific legislation.



Patent authority	Fraction of International Patent Families with at least one patent granted by the authority (percent)
African Regional Intellectual Property Organisation (ARIPO)	0.5
Eurasian Patent Organization (EAPO)	1.2
European Patent Office	22.8
African Intellectual Property Organization (OAPI)	0.2

Figure 10

Proportion of International Patent Families in the field of mRNA-based vaccines for which at least one patent or utility model was granted or registered in a specific legislation. See Section 3 for information on the proportion of EP applications for which a European patent was granted.



Source: authors' calculations

Table 1

Most active applicants in the field of mRNA-based vaccines

Applicant	Country	Sector allocation	Number of International Patent Families
Moderna	US	Company	96
CureVac	DE	Company	95
Biontech	DE	Company	56
GSK (GlaxoSmithKline)	GB	Company	49
Government of the United States of America	US	Governmental / non-profit organisation	42
Novartis	CH	Company	39
Johannes Gutenberg Universität Mainz	DE	University	35
Gilead Sciences	US	Company	26
Harvard University	US	University	21
Sanofi	FR	Company	18
Johnson & Johnson	US	Company	17
University of Pennsylvania	US	University	16
Johns Hopkins University (JHU)	US	University	16
Enanta Pharmaceuticals	US	Company	15
Sun Yat-Sen University	CN	University	14
Wistar Institute	US	Governmental / non-profit organisation	13
Massachusetts Institute Of Technology (MIT)	US	University	13
Vical	US	Company	12
University of California	US	University	12
Bayer	DE	Company	12

Table 2

Breakdown for the most active applicants in the field of mRNA-based vaccines, for the periods 1990-1999, 2000-2009, 2010-2019 and 2020-2021

Applicant	Country	Sector allocation	Number of International Patent Families
1990-1999			
GSK (GlaxoSmithKline)	GB	Company	7
University of California	US	Company	5
Government of the United States of America	US	Governmental/ non-profit organisation	2
Sanofi	FR	Company	2
Ribogene	US	Company	2
Connaught Laboratories	CA	Governmental / non-profit organisation	2
The Immune Response Corporation	US	Company	2
Duke University	US	University	2
University of Maryland	US	University	2
2000-2009			
Government of the United States of America	US	Governmental / non-profit organisation	22
CureVac	DE	Company	14
Vical	US	Company	11
Sanofi	FR	Company	11
Bayer	DE	Company	11
Johns Hopkins University (JHU)	US	University	10
Steve Pascolo	CH	Individual	9
Novartis	CH	Company	7
GSK (GlaxoSmithKline)	GB	Company	7
2010-2019			
Moderna	US	Company	74
CureVac	DE	Company	72
Biontech	DE	Company	33
Novartis	CH	Company	32
GSK (GlaxoSmithKline)	GB	Company	31
Johannes Gutenberg Universität Mainz	DE	University	26
Enanta Pharmaceuticals	US	Company	15
Sun Yat-Sen University	CN	University	13
Government of the United States of America	US	Governmental / non-profit organisation	11

Applicant	Country	Sector allocation	Number of International Patent Families
2020-2021			
Moderna	US	Company	22
Biontech	DE	Company	20
Gilead Sciences	US	Company	19
Harvard University	US	University	9
CureVac	DE	Company	9
Wistar Institute	US	Governmental / non-profit organisation	7
Vanderbilt University	US	University	7
University of Florida	US	University	7
Government of the United States of America	US	Governmental/ non-profit organisation	7
Johannes Gutenberg Universität Mainz	DE	University	7
eTheRNA Immunotherapies	BE	Company	7
Johnson & Johnson	US	Company	7

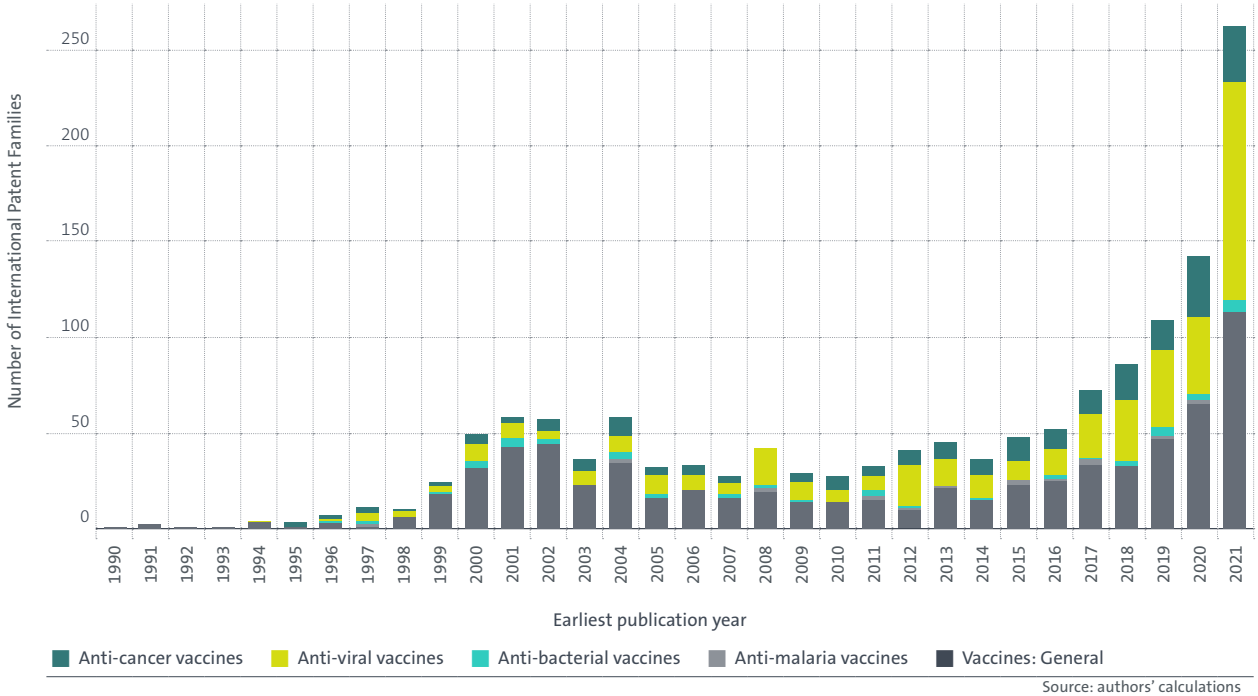
Table 3

List of patent applicants in the field of mRNA-based vaccines frequently seeking patent protection jointly with other applicants. This list presents the patent applicants with the highest number of International Patent Families having at least a second patent applicant from another entity.

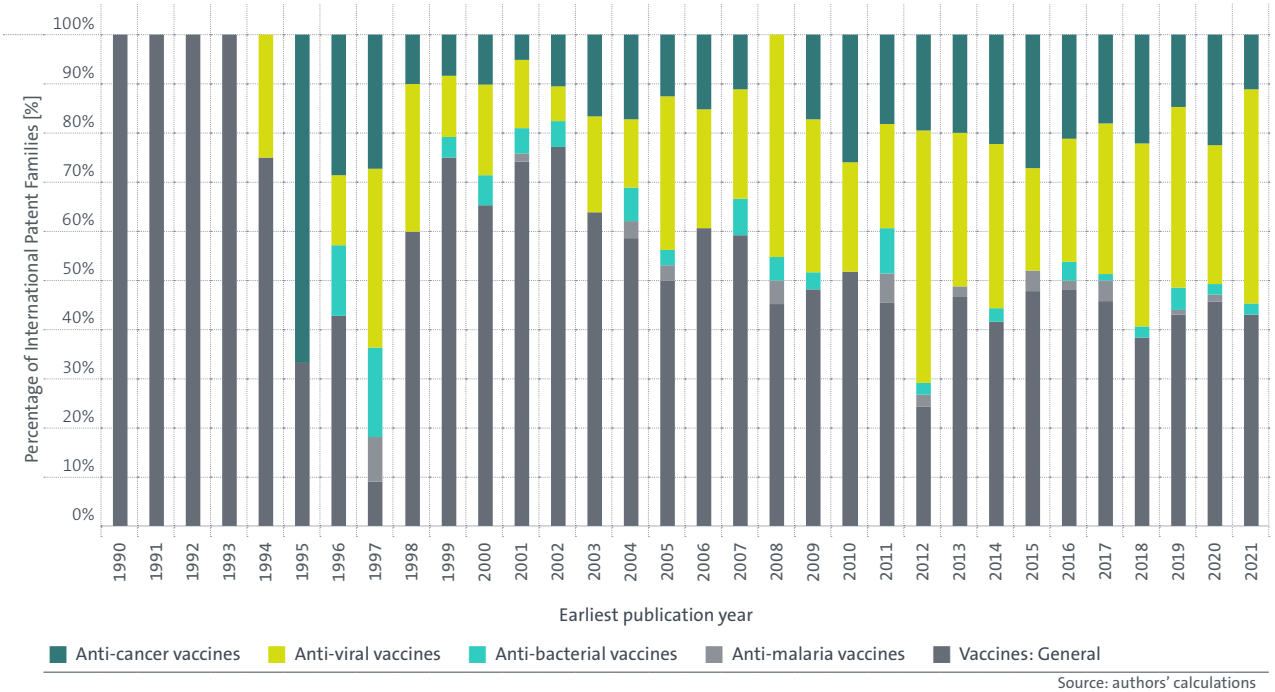
Applicant	Country	Sector allocation	Number of International Patent Families with at least one joint patent application
Biontech	DE	Company	39
Johannes Gutenberg Universität Mainz	DE	University	34
Government of the United States of America	US	Governmental / non-profit organisation	15
Harvard University	US	University	14
Massachusetts Institute Of Technology (MIT)	US	University	13
GSK (GlaxoSmithKline)	GB	Company	12
University of Pennsylvania	US	University	10
The Broad Institute	US	Governmental / non-profit organisation	9
Centre national de la recherche scientifique (CNRS)	FR	Governmental / non-profit organisation	8
Sanofi	FR	Company	7

Figure 12a + 12b

Thematic focus of International Patent Families in the field of mRNA-based vaccines according to important groups of vaccines (anti-cancer vaccines, anti-viral vaccines, anti-bacterial vaccines and anti-malaria vaccines), per earliest publication year. The absolute number of International Patent Families are shown at top, and the percentage of the four important groups of vaccines at bottom.



Source: authors' calculations



Source: authors' calculations

Figure 13

Thematic focus of International Patent Families of active applicants in the field of mRNA-based vaccines, broken down according to popular vaccines against cancer, viruses, bacteria, and malaria

				Anti-viral vaccines								
					dsDNA virus					Reverse transcribing DNA virus	Reverse transcribing RNA virus	
Applicant	Country	mRNA-based vaccines: Total	Anti-cancer vaccines	Anti-viral vaccines	Cytomegalo-virus vaccine	Herpessim-plex vaccine	Papilloma-virus vaccine	Poxvirus vaccine	Rotavirus vaccine	Varicella vaccine	Hepatitis B vaccine	HIV vaccine
Moderna	US	96	8	33	2	4	1			2		1
CureVac	DE	95	31	34			1		2		1	
Biontech	DE	56	28	9	1							
GSK (GlaxoSmithKline)	GB	49		33	11	3	2			3		3
Government of the United States of America	US	42	1	25				1				7
Novartis	CH	39		27	12					3		3
Johannes Gutenberg Universität Mainz	DE	35	20	4	1							
Gilead Sciences	US	26		1								1
Harvard University	US	21	6	5								1
Sanofi	FR	18	1	7								
Johnson & Johnson	US	17	1	11							7	1
JHU (Johns Hopkins University)	US	16	4	7	1		2					
University of Pennsylvania	US	16	4	8		2						1
Enanta Pharmaceuticals	US	15										
Sun Yat-Sen University	CN	14										
MIT (Massachusetts Institute Of Technology)	US	13	2	2								1
Wistar Institute	US	13	4	9			1					1
Bayer	DE	12										
University of California	US	12	4	4								1
Vical	US	12		7	1	1						

Number of IPFs

0 40

Figure 13 continued

Thematic focus of International Patent Families of active applicants in the field of mRNA-based vaccines, broken down according to popular vaccines against cancer, viruses, bacteria, and malaria

		Anti-viral vaccines							Anti-bacterial vaccines		
		Positive strand ssRNA virus			Negative strand ssRNA virus						
Applicant	**Country**	**Coronavirus vaccine**	**Flavivirus vaccine**	**Rhinovirus vaccine**	**Ebolavirus vaccine**	**Influenza-virus vaccine**	**Pneumo-virus vaccine**	**Rabiesvirus vaccine**	**Anti-bacterial vaccines**	**Mycobacte-rium vaccine**	**Anti-malaria vaccines**
Moderna	US	6	6		2	5	5		1		1
CureVac	DE	2	2		1	17	5	7			1
Biontech	DE	3				3					
GSK (GlaxoSmithKline)	GB		1			2	20	3			1
Government of the United States of America	US	3	3		1	2	2		1	1	4
Novartis	CH					1	18				
Johannes Gutenberg Universität Mainz	DE					1					
Gilead Sciences	US										
Harvard University	US					4			2		
Sanofi	FR		3	1		1					
Johnson & Johnson	US	2				1	1		1	1	
JHU (Johns Hopkins University)	US	1	2						1		
University of Pennsylvania	US	1	2			1			3	1	
Enanta Pharmaceuticals	US										
Sun Yat-Sen University	CN										
MIT (Massachusetts Institute Of Technology)	US		1		1	1	1				
Wistar Institute	US	1	1			1					
Bayer	DE										
University of California	US	2				1					
Vical	US	1				3			1		1

Number of IPFs

0 40

4. Conclusions and outlook

This report shows that while patent application numbers are still low, the field of mRNA-based vaccines is very dynamic and the momentum in this field is clearly above average compared with the general increase in patent application numbers across all fields of technology in the recent past.

One important finding of the report is the key role of applicants from the United States, Europe and China. The most active applicants in the field of mRNA-based vaccines are companies and universities. The list of active applicants is headed by Moderna and CureVac, which have submitted patent applications for a wide range of vaccine targets, whereas other active applicants have remained either quite focussed or unspecific in terms of their respective vaccine targets.

In view of the high momentum in the field of mRNA-based vaccines and the high number of exciting inventions in this area, the EPO intends to update this report in the future and expand it to include other relevant mRNA technologies.

Annex

Notes on the limits of the study

This report provides a snapshot of the field of mRNA-based vaccines as a particularly dynamic area of mRNA technologies, taken in the light of patent data.[15] The methodology on which this report is based can be used freely, i.e. everyone can adapt the chosen search and analysis approach to their needs, for example to follow trends and developments in other established or emerging technical fields.

This report makes use of publicly available EPO worldwide patent data as well as EPO in-house and publicly available search and analysis tools.

Like many patent analyses, this report is based on dedicated search strategies combining keywords and patent classification symbols. The search strategies are included in the supplementary materials document that accompanies this report.

For most patent analyses, it is impossible to simultaneously achieve 100% recall – i.e. to retrieve as many relevant documents as possible – and 100% precision, i.e. to exclude as many non-relevant documents as possible. This study is no exception. The search queries chosen to create the basic dataset for the field of mRNA-based vaccines were designed to strike a balance between recall and precision in order to provide a meaningful overview of the field.

15 Date of extraction of the basic dataset from the EPO's internal data platform: August 2023. The basic dataset was combined with data from the EPO's PATSTAT product line (Spring 2023 edition), which used backfile data from the EPO's master documentation database (DOCDB) extracted in February 2023.

Published and edited by
European Patent Office
Munich
Germany

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Design
European Patent Office

The report can be downloaded from:
epo.org/insight-mrna-technologies

ISBN 978-3-89605-368-8