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Research Article

# Emeritus Professor Dr. Ian Hector Frazer, the Pioneer of HPV Vaccine against Cervical Cancer in Women: A Bio-Bibliographic Assessment

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## ABSTRACT

**Aim:** This paper aims to provide an assessment of cervical cancer research related to Human Papillomavirus (HPV) infections, with a particular focus on the scientific contributions of Dr. Ian Hector Frazer, a Scottish-born Australian immunologist. He is best known for co-developing the HPV vaccine, a major breakthrough in cervical cancer prevention. This study encompasses an analysis of 573 publications from 1997 to 2024, applying bibliometric techniques to quantitatively assess Dr. Frazer's scholarly output, presenting a comprehensive portrait of his impact on the field. **Background:** Historical records of cervical cancer trace back to 400 BCE, when it was considered an untreatable illness. Over time, extensive research led to the discovery of its viral cause "Human Papillomavirus (HPV)" and eventually to the development of a preventive vaccine. A major breakthrough came in 2006 with the introduction of the HPV vaccine, which significantly reduced the risk of cervical cancer in women. This landmark achievement is credited to Dr. Ian Frazer, whose ground-breaking work marked a turning point in the fight against cervical cancer, widely recognized as a pioneering figure of the 21st century for his invention of the HPV vaccine. **Methodology:** The data of Dr. Frazer's 573 publications were primarily harvested from Google Scholar (GS) and Dr. Frazer's institutional profile at the Frazer Institute, The University of Queensland, Australia. Attention was given on selection of various bibliographical elements from all publications. After careful filtration and validation, the publication data were compiled and organized using Microsoft Excel and Word to facilitate tabulation and further analysis. Standard bibliometric techniques of different informetric indicators were employed to conduct a comprehensive scientometric assessment, culminating in the creation of a medicometric profile of Dr. Frazer's scholarly contributions to medical science. **Findings:** Dr. Ian Frazer has authored a total of 573 publications over a span of 48 years in cancer research. Among these, 76 are single-authored works, while 496 are collaborative publications. The majority of his contributions are journal articles and the highest number of his papers i.e. 26 in total has appeared in the journal *Virology*. His first publication appeared in 1977, at the age of 24, and his most productive period occurred between 2002 and 2006 with 100 papers. His most frequent collaborator is G.J. Leggatt, with whom he co-authored 76 papers. The median age of his research productivity is 30, and his Productivity Coefficient is calculated at 0.63, indicating a high level of consistent output, averaging nearly 12 publications per year. His most cited work, published in 1997, has received 1,325 citations according to the Scopus database. Additional interfaces have been derived from this bibliometric investigation. **Conclusion:** Although numerous bio-bibliometric studies have been conducted in the domain of bibliometric research, no comprehensive analysis has yet been undertaken on the scientific contributions of Dr. Ian Frazer, an eminent medical scientist. This study, therefore, represents an original and significant effort that offers valuable insights for cancer researchers, medical historians, educators, students, librarians, information scientists, biographers, and other knowledge seekers interested in the development of cancer immunology and vaccine research.

**Keywords:** Ian Hector Frazer, Ian Frazer, Human Papillomavirus (HPV), Cervical Cancer, Cervix Uteri, Female Cancer, Cancer Research, Immunologist, Bio-Bibliometric Study, Bibliometric, Informatics, Citation Growth Rate, Relative Growth Rate, Doubling Time, Fifty-Percentile Age, Collaboration Coefficient (CC), Collaboration Index (CI), Modified Collaboration Coefficient (MCC).

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## INTRODUCTION

Cancer can develop in various organs of the human body, and its name typically reflects the specific organ it affects. Globally, the number of cancer cases is steadily rising, prompting scientists and researchers to work relentlessly toward finding effective treatments. One significant form of cancer is cervical cancer, which originates in the cervix, the lower part of the uterus in women. According to GLOBOCAN 2022, there were approximately 662,301 new cases and 348,874 deaths from cervical cancer worldwide. In the United States alone, around 14,000 women are diagnosed with cervical cancer each year, with the highest incidence occurring in women between the ages of 35 and 44 (Cleveland Clinic, 2025). In India, according to the World Health Organization, 2022, cervical cancer ranks as the second

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most common cancer, accounting for 125,126 new cases and 79,906 deaths (GLOBOCAN, 2022).

## Cervical Cancer

Cervical cancer starts in the cervix, the lower part of a woman's uterus (or womb) that connects to the vagina, also known as the birth canal. Globally, it is the fourth most common cancer among women (WHO, 2025) and ranks among the top ten cancer types worldwide (WHO Global Cancer Observatory, 2024). In simple terms, cervical cancer is characterized by abnormal cell growth in the cervix. The majority of cases are linked to persistent infection with the Human Papillomavirus (HPV), a common sexually transmitted virus spread through sexual contact (Mayo Clinic, 2025).

## Historical Background of Cervical Cancer and HPV

The history of cervical cancer research spans over two millennia, beginning with early observations and culminating in significant medical breakthroughs in diagnosis, prevention, and treatment (Wikipedia, 2025; Lowy, 2024; Masonic Cancer Center, 2022; Teal Health, 2024):

- 400 BCE: The Greek physician ***Hippocrates*** first noted that cervical cancer was incurable, laying the foundation for centuries of medical curiosity.
- 1925: ***Hans Hinselmann*** developed the ***colposcope,*** an instrument for examining the cervix, aiding in early visual detection of abnormalities.
- 1928: Greek scientist ***Dr. George Papanicolaou*** observed precancerous, HPV-associated lesions in vaginal smears, a major step toward cervical cancer screening.
- 1941: Papanicolaou, in collaboration with Herbert Traut, introduced the ***Pap smear test***, a screening method that significantly improved early detection of cervical cancer.
- 1946: The ***Aylesbury spatula*** was developed to collect cervical samples more effectively for Pap smear analysis.
- 1949: ***Strauss et al.***, provided the first electron microscopy images of the ***Human Papillomavirus (HPV)***, identifying a possible viral link to cervical cancer.
- 1963: ***Crawford and Crawford*** detailed the physical properties of ***HPV DNA***, paving the way for molecular studies of the virus.
- 1970s: Renowned virologist ***Harald zur Hausen*** first hypothesized a connection between ***HPV and cervical cancer,*** earning him the title "Father of HPV Virology."
- 1976: Zur Hausen published his theory linking HPV to cervical cancer.
- 1983: He conclusively demonstrated that ***HPV genes integrate into the host DNA*** in cervical cancer cells. This breakthrough transformed our understanding of viral oncology.
- 2006: The first ***HPV vaccine*** was developed ***by Dr. Ian Frazer and his team*** and approved by the ***U.S. FDA***, marking a new era in cervical cancer prevention.
- 2008: Harald zur Hausen was awarded the ***Nobel Prize in Medicine*** for his discovery of the role of HPV in causing cervical cancer.
- 2015: Studies confirmed that the ***HPV vaccine provides protection*** at multiple anatomical sites, expanding its significance in public health.
- 2018: Evidence emerged supporting ***single-dose HPV vaccine protection***, making global immunization efforts more feasible and cost-effective.

## Human Papillomavirus (HPV)

HPV, sexually transmitted virus, can affect areas like the skin, genitals, and throat. Most people get HPV at some point in their lives without any signs and symptoms, and in many cases, the immune system clears the virus on its own (Mayo Clinic, 2025; WHO, 2025; NIH, USA, 2023). However, some types of HPV or persistent infection with high-risk HPV can stay in the body and cause changes in the cells of the cervix, called *dysplasia*. If these abnormal cells aren't treated, they can slowly turn into cancer over time and spread deeper into the cervix tissue or potentially to nearby organs. Cervical cancer usually develops over many years.

## Symptoms

Cervical cancer usually doesn't show symptoms in the early stages. As it grows, some common signs may appear (Mayo Clinic, 2025; Wikipedia, 2025), such as:

- Unusual vaginal bleeding, especially after sexual intercourse, between menstrual periods, or after menopause (contact bleeding is one of the most common signs).
- A lump or abnormal growth in the vagina or vaginal wall like cysts.
- Heavier or longer menstrual bleeding.
- Watery or bloody vaginal discharge with bad smell.
- Bleeding after douching or a pelvic examination.
- Pain in the pelvis or pain during sexual intercourse.
- In more advanced stages, cervical cancer may cause additional symptoms such as:
- Loss of appetite and weight.

- Feeling tired all the time i.e. fatigue.
- Pain in the back or legs.
- Swelling in the legs.
- Bone pain or fractures.
- Bleeding from the rectum, or blood in the urine.
- In rare cases, leakage of urine or stool (feces) from the vagina.

If abnormal bleeding, unusual vaginal discharge or any other unexplainable symptoms are seen for any one, it is necessary to contact a healthcare provider.

### Treatment

The treatments for cervical cancer are radiation, chemotherapy, surgery, targeted therapy, immunotherapy and other cancer medications (Cleveland Clinic, 2025).

### Prevention

Regular gynaecological examinations and Pap tests are among the most effective measures for preventing cervical cancer. Additional key prevention strategies include (Cleveland Clinic, 2025; WHO, 2025):

- ***HPV Vaccination*:** Receiving the HPV vaccine-especially all girls between the ages of 9 and 14 is safe and highly effective in preventing HPV infection, cervical cancer, and other HPV-related diseases. Because at this stage they are not sexually active. The most common vaccine is ***Gardasil 9***, which protects against 9 types of HPV, including the most dangerous.
- ***Screening:*** Routine cervical screening starting at age 30 (or from age 25 for women living with HIV) can detect early cervical disease. Timely treatment of such conditions helps prevent cancer from developing. For women, Pap smears and HPV tests help detect early signs of cervical changes or infection.
- ***Early Detection and Treatment:*** At any age, the presence of symptoms or concerns should prompt immediate medical evaluation. Early detection followed by appropriate treatment can result in a complete cure.
- ***Safe Sexual Practices*:** Using condoms and reducing the number of sexual partners can lower the risk of HPV transmission.
- ***Avoid Tobacco Use*:** Quitting smoking and avoiding tobacco products reduces the risk of cervical and other cancers.

It's a highly treatable cancer, especially if it's caught in the early stages.

This episode begins with cervical cancer and the pioneer of first HPV Vaccine for the treatment of cervical cancer, Dr. Professor Ian Hector Frazer is a Scottish-born Australian immunologist renowned. Frazer has authored numerous scientific papers and has been instrumental in advancing cancer immunotherapy research. His work continues to influence the fields of immunology and vaccine development.

## BRIEF BIOGRAPHY OF DR. IAN FRAZER

### Early Life and Education

Dr. Ian Frazer was born on 6 January 1953 in Glasgow, Scotland, to Marion Shepherd, a medical scientist specializing in diabetic neuropathy, and Sam Frazer, a physician and head of a diagnostic pathology laboratory (Embryo Project Encyclopedia, 2020). His exposure to science began early, inspired by his parents' academic careers. In 1955, the family relocated to Edinburgh, where he attended George Watson's College for his primary education. A subsequent move in 1964 took them to Aberdeen, where Frazer completed his secondary education. He enrolled at the University of Edinburgh to study medicine, earning a B. Sc (Bachelor of Science) in 1974 and a Bachelor of Medicine, Bachelor of Surgery (MBBS) in 1977. His academic development included a formative three-month placement at the Walter and Eliza Hall Institute of Medical Research in Melbourne, Australia. Frazer returned there in 1981 to pursue research in viral immunology and autoimmunity, focusing on Human Papillomaviruses (HPV). He was awarded a Doctor of Medicine (MD) i.e. Ph D. from the University of Melbourne in 1988 (Australian Academy of Science, 2025). Ian Frazer lives in Brisbane, Australia with his wife Caroline whom he married in 1976. As of 2010, two of his sons are medical students and the third is a veterinary scientist (Wikipedia, 2024).

### Professional and Research Activities

Dr. Ian Hector Frazer is a Scottish-born Australian immunologist, best known for his pioneering work on the Human Papillomavirus (HPV) and the development of vaccines against HPV-related cancers, particularly cervical cancer. Now, Dr. Ian Frazer leads the Translational Research Institute in Australia as its founding CEO and Director of Research. His journey there began after completing his residency in several Scottish hospitals between 1978 and 1979, including the Edinburgh Royal Infirmary and Roodlands General. In 1985, after moving to Brisbane, he took up a teaching position at the University of Queensland. It was there that he reunited with Dr. Jian Zhou, a brilliant molecular virologist. Their collaboration would prove ground-breaking and culminating in the creation of a vaccine that prevents HPV infection and significantly reduces the risk of cervical cancer. In 1980-81, Frazer immigrated to Melbourne after being recruited by Dr. Ian Mackay to join the Walter and Eliza Hall Institute of Medical Research, where he focused on viral immunology. In 1981, he identified that the immunodeficiency observed among

homosexual men in San Francisco also affected participants in his hepatitis B study. His work in 1984 helped confirm that HIV was a causative agent of AIDS. Concurrently, he observed that infection with Human Papillomavirus (HPV), another sexually transmitted virus, was associated with the development of precancerous cellular changes. In 1985, Frazer joined the University of Queensland as a Senior Lecturer, where he established his own laboratory within the Lions Human Immunology Laboratories. There, he advanced research on HPV in men and contributed to ongoing HIV studies. He also taught, conducted diagnostic testing at the Princess Alexandra Hospital, and was awarded a Doctor of Medicine degree in 1988. In 1990, Frazer and his team began employing molecular biology techniques to synthesize Virus-Like Particles (VLPs) that mimicked the structure of HPV. Under Frazer's guidance, in March 1991, Xiao-Yi Sun, working with her husband Jian Zhou, successfully assembled "*two HPV proteins into a VLP*" that resembled the virus's outer shell-laying the foundation for the HPV vaccine. The resulting vaccine offered complete protection to unexposed women against four HPV strains responsible for approximately 70% of cervical cancers. A provisional patent was filed in June 1991, and development commenced at the University of Queensland (UQ). To support clinical trials, partial patent rights were licensed to CSL in Australia and Merck internationally. CSL retained exclusive rights for Australia and New Zealand, while Merck held rights elsewhere. GlaxoSmithKline independently developed a similar VLP-based vaccine, Cervix, and licensed Frazer's IP in 2005. Later in 1991, Frazer presented the research at a scientific conference in the United States and was appointed Director of UQ's Centre for Immunology and Cancer Research (later renamed The Diamantina Institute). Gardasil entered the design phase shortly thereafter, leading to clinical trials, and Frazer was promoted to Professor in UQ's Department of Medicine. In 1998, human trials for Gardasil were completed, and Frazer became an Australian citizen (Wikipedia, 2024; Britannica, 2025). The first vaccine against HPV was developed by Ian Frazer. It was approved in 2006 by the U.S. Food and Drug Administration for use in girls and young women age 9 to 26 and was sold under the trade name Gardasil (Britannica, 2025).

## Current Research

Presently he is doing research on different infections and vaccine (Wikipedia, 2024). It may include:

I.In February 2014, it was announced that Frazer's new vaccine against genital herpes has passed human safety trials in a trial of 20 Australians. The vaccine is designed to prevent new infections.

II.Others are:

- Immunoregulation and immunotherapeutic vaccines, supported by several US and Australian research funding bodies.
- A VLP-based vaccine against hepatitis C.
- The VLP production technology for dengue fever, and Japanese encephalitis vaccines.
- HIV Vaccine (50% effective) that may be available by 2028.
- Already trial going on of the first vaccine for skin cancer (the Squamous cancer, caused by HPV).

## Research Implications

The implementation of the HPV vaccine has been guided by health authorities such as the U.S. FDA and CDC, with the following key recommendations (Mayo Clinic, 2025a):

1. ***Vaccine Approval and Use***

   Gardasil 9 has been approved by the U.S. Food and Drug Administration (FDA) for individuals aged 9 and older. It may be administered concurrently with other routine vaccinations.

2. ***Recommended Age for Vaccination***

   The Centres for Disease Control and Prevention (CDC) recommends routine HPV vaccination at ages 11 or 12, ideally before the onset of sexual activity to ensure maximum effectiveness.

3. ***Effectiveness Post-Infection***

   The vaccine is most effective when administered prior to HPV exposure. Once infected, the vaccine does not treat or clear the existing virus, though it may still offer protection against other strains.

4. ***No Impact on Sexual Behaviour***

   Studies have shown that receiving the HPV vaccine at an early age does not correlate with an earlier initiation of sexual activity.

5. ***Dosing Schedule for Younger Individuals***

   For individuals under 15 years of age, a two-dose schedule is recommended, with the doses spaced 6 to 12 months apart.

6. ***Dosing Schedule for Older Adolescents and Adults***

   For those aged 15 to 26 years beginning the vaccination series, a three-dose regimen over a six-month period is advised.

## Awards, Honours and Achievements

Professor Ian Frazer is a renowned immunologist who co-developed the technology behind the HPV vaccines that have significantly reduced the incidence of cervical cancer worldwide.

His awards and honours include (International Balzan Prize Foundation, n.d.; Wikipedia, 2024):

- **1999:** Australian Biotechnology Award; Business/ Higher Education Round Table Award for Collaborative Research.
- **2003:** Centenary Medal for services to cancer research.
- **2005:** John Curtin Medal; CSIRO Eureka Prize for Leadership in Science.
- **2006:** Distinguished Fellowship Award from the Royal College of Pathologists; Queenslander of the Year and Australian of the Year; William B. Coley Award (shared with Harald zur Hausen).
- **2007:** Novartis Prize for Clinical Immunology; Golden Plate Award (American Academy of Achievement); International Life Award for Scientific Research; Clunies Ross Award; Howard Florey Medal for Medical Research.
- **2008:** Prime Minister's Prize for Science; Balzan Prize for Preventive Medicine; Ramaciotti Medal; Lila Gruber Award (American Academy of Dermatology).
- **2009:** Australian Medical Association Gold Medal.
- **2011:** Elected Fellow of the Royal Society (FRS).
- **2012:** Named a National Living Treasure (National Trust of Australia, NSW); Appointed Companion of the Order of Australia (AC).
- **2018:** Elected Corresponding Fellow of the Royal Society of Edinburgh.
- **2022:** Awarded the Grand Hamdan International Award in Infectious Diseases.

### Fellowships

Dr. Ian Frazer also had several fellowships, such as,

- Royal College of Physicians of Edinburgh (1988-).
- Royal College of Pathologists of Australasia (1989-).
- Australian Institute of Company Directors (2002-).
- Australian Academy of Technological Sciences and Engineering (2003-).
- Australian Academy of Science (2004-).
- Australian Academy of Health and Medical Sciences (2014-).

## REVIEW OF LITERATURE

A significant number of bio-bibliometric or scientometric studies have been undertaken by librarians and information scientists over the past decades. These studies have primarily focused on assessing the research productivity, impact, and biographical contributions of eminent scientists and academicians across various disciplines. Below is a chronological overview of such notable works. Varaprasad *et al.*, (2010) conducted a bibliometric assessment of J. S. Yadav's contributions to chemical sciences. In the same year, Sangam and Savanur (2010) explored the life and scholarly legacy of Eugene Garfield, regarded as a foundational figure in bibliometrics and scientometrics. Mukherjee (2013) analysed the research output of Prof. Lalit Singh, while Manjunath and Ramesha (2015) studied the biography and publications of Nobel Laureate Sir C. V. Raman. Koley and Sen (2016, 2017) examined the scholarly contributions of V. L. Kalyane, a pioneer in biobibliometrics, and presented a scientometric portrait of the renowned astronomer Jan Hendrik Oort, respectively. Mondal, Raychoudhury, and Sarkhel (2018) produced a bio-bibliometric account of Prof. P. C. Mahalanobis, a distinguished Indian statistician. Dutta (2019) evaluated the works of Prof. B. K. Sen, an information scientist and scientometrician. Yasmin (2019) analysed the research publications of Prof. Kasi Pitchumani in the field of chemistry. Teli and Maity (2021) conducted a bibliometric analysis of physicist Stephen Hawking's scholarly contributions. Hussain and Shakoor (2022) studied the work of Dr. Saeed Ullah Jan in the field of Library and Information Science. In 2023, Shivaraja O assessed the research output of Prof. K. R. Venugopal, an academician in Electronics, Computer Science, and Information Science Engineering. Huded *et al.*, (2023) provided a statistical evaluation of Prof. Madhav Gadgil, an ecologist and environmental scientist. Koley (2023, 2024) conducted separate scientometric analyses on Prof. Subhas Mukherjee, creator of India's first IVF baby, and Prof. Dilip Mahalanobis, innovator of Oral Rehydration Solution (ORS). Behera and Meher (2024) analyzed the economic research of Dr. Raghuram Rajan, former Governor of the Reserve Bank of India. In the same year, Kavi and Singh (2024) studied the contributions of aerospace scientist Poddam Narasimha. Most recently, Koley (2025) presented a bio-bibliographic study on Dr. Suprabhat Mukherjee, a colon cancer researcher. Despite the breadth of these analyses, a scientometric evaluation of Dr. Ian Frazer, a leading medical scientist best known for his role in developing the HPV vaccine, remains unaddressed. Therefore, the present study aims to fill this gap by providing a comprehensive bibliometric assessment of Dr. Frazer's research contributions.

## OBJECTIVE OF THE STUDY

The main objectives of this study are:

**a.** To prepare a year- and age- wise research outputs of Professor Ian Frazer between 1977 and 2024.

**b.** To determine his position as main author and co-author.

**c.** To examine and analyse authorship patterns.

**d.** To measure the DC, IC, CC, MCC from his publication patterns.

**e.** To learn about leading collaborators.

**f.** To find out peak period of productivity.

**g.** To identify channel wise scattering of publications.

**h.** To analyse citation received from his papers.

**i.** To calculate Relative Growth Rate and Doubling Time.

**j.** To test validation of the Lotka's Law and Bradford's law.

## METHODOLOGY

This study encompasses a total of 573 research publications authored by Dr. Ian Frazer, spanning the period from 1977 to 2024. These works appear in diverse formats, including journal articles, conference papers, book chapters, books, letters, research reports, patents, preprints, erratum and corrections, and audio documents. The data were primarily sourced from Google Scholar (GS) and Dr. Frazer's institutional profile at the Frazer Institute, The University of Queensland, Australia (Frazer Institute, n.d.). After careful filtration and validation, the publication data were compiled and organized using Microsoft Excel and Word to facilitate tabulation and further analysis. In addition to these primary sources, supplementary information was retrieved from a variety of online and offline resources. Further biographical details and insights into Dr. Frazer's academic career, scientific accomplishments, and personal milestones were collected via publicly accessible internet sources. Standard bibliometric techniques were employed to conduct a comprehensive scientometric assessment, culminating in the creation of a medicometric profile of Dr. Frazer's scholarly contributions to medical science. The subsequent sections present the key findings and interpretations derived from this analysis.

## DATA ANALYSIS AND DISCUSSION

### Year-wise and Age-wise Publications

Table 1 presents the year-wise and age-wise distribution of Dr. Ian Frazer's research publications. Over a productive academic span of 48 years, he has authored a total of 573 publications in various formats. The year 2004, corresponding to age 51, marked the peak of his scholarly output with 28 publications, followed by 22 publications each in 1999 (age 46) and 2002 (age 54). Similarly, 21 publications each were recorded in 2001 (age 48), 2006 (age 53), and 2010 (age 57). Excluding the years 1978 and 1979, Dr. Frazer published at least one or more paper in every other year between 1977 and 2024. His first research output appeared in 1977, at the age of 24. A few publications remain undated due to the unavailability of imprint information. The Degree of Collaboration (DC), calculated using standard bibliometric methods, stands at 0.85, indicating a strong tendency toward collaborative research. Of his total output, 76 papers were single-authored, while 496 were multi-authored. Dr. Frazer had published approximately 50% of his total output 569 (i.e., 569/2 = 284.5 or 285 publications nearly) by the time he reached the age of 30, during a total productive span of 48 years up to the year 2024. Following the method proposed by Sen and Gan (1990) and recently applied by Kavi and Singh (2024), the Productivity Coefficient is calculated as 50 percentile age divided by total productive age i.e. Here 30/48=0.0.63. On average, his publication rate is 573/48≈11.93, or approximately 12 publications per year.

### Quinquennium-wise Publications

Table 2 presents the quinquennium-wise (five-year block) distribution of Dr. Ian Frazer's research publications, while Figure 1 graphically illustrates the same, highlighting his peak periods of productivity. The highest number of publications-100 papers-was recorded during the sixth quinquennium (2002-2006), when Dr. Frazer was between the ages of 54 and 58, averaging 20 papers per year. This was followed by 87 publications in the 2007-2011 period (ages 59-63), and 83 publications during 2017-2021 (ages 69-73). Other productive periods include 1997-2001, with 74 publications (ages 49-53), and 2012-2016, with 71 publications (ages 64-68), among others. These findings suggest sustained research output over multiple decades, with particularly high productivity in the early 2000s and again in the later stages of his career.

### Authorship Pattern

#### *Collaborative and Non-collaborative Publications*

Table 3 outlines Dr. Ian Frazer's authorship patterns. He has **77 single-authored papers**, with the years of **three o**f these papers unidentifiable. The remaining 74 were published over **39 years**. His **496 collaborative works** include: • 67 two-authored (TS 39 years) • 46 three-authored (TS 46 years) • 66 four-authored (TS 38 years) • 71 five-authored (TS 41 years) • 59 six-authored (TS 41 years) • 44 seven-authored (TS 40 years). He also has 88 highly collaborative (mega-authored) papers-12 with ten authors, and 76 with more than ten co-authors, demonstrating his extensive involvement in large-scale research collaborations.

### CoA, CC, CI and MCC

Table 4 presents the year-wise distribution of co-authors (CoAs), along with calculated values for the Collaboration Coefficient (CC), Collaboration Index (CI), and Modified Collaboration Coefficient (MCC) (Yadav, Singh, and Verma, 2019; Ravichandra and Rajendra, 2024) for Dr. Ian Frazer's publications. Out of a total of 3,675 authors, 3,102 were co-authors, indicating a strong collaborative trend throughout his career. The highest number of co-authors was recorded in 2014, with 214 CoAs contributing to 12 publications, followed by 156 CoAs in 2019 for 18 papers,

152 in 2018 for 15 papers, and 151 in 2020 for 18 publications. The Collaboration Coefficient (CC) reached its peak at 0.92 in 2024, while the lowest value was 0.39 in 2006. A CC value of 0.22 for three undated publications has been excluded due to the uncertainty in publication year (n.d.). The average CC over the study period (1977-2024) stands at 0.68. The Collaboration Index (CI), representing the average number of authors per paper, ranged from a minimum of 2.64 in 2007 to a maximum of 18.83 in 2011, with an average CI value of 6.41. Similarly, the Modified Collaboration Coefficient (MCC) reached a maximum of 1.02 in 2024, while the lowest values (0.00) were recorded in 1977 and 1980. The average MCC is also 0.68, aligning with the average CC value, further confirming a high level of collaborative research throughout the study period.

## Authorship Status Byline of Authors

Table 5 illustrates Dr. Ian Frazer's placement in the author byline across his 496-collaborative works. Most frequently, he appeared as the first author in 75 publications, followed by 66 appearances in the second position and 56 as third author. He was listed 68 times each in both the fourth and fifth positions, reflecting consistent mid-level authorship roles. Notably, in several large-scale collaborative projects, he was placed in later positions, including the 10th position in 15 papers and positions beyond 10th in 41 papers, ranging as far as the 163rd position. These findings suggest Dr. Frazer played diverse roles in his collaborative projects-ranging from lead author to senior or contributing co-author in large, multi-author studies typical of medical and biomedical research.

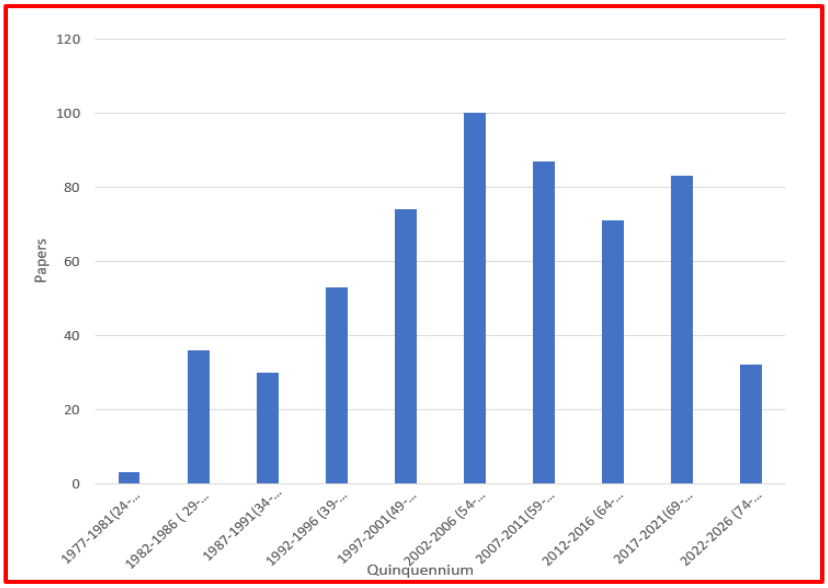


**Figure 1:** Peak period of productivity.

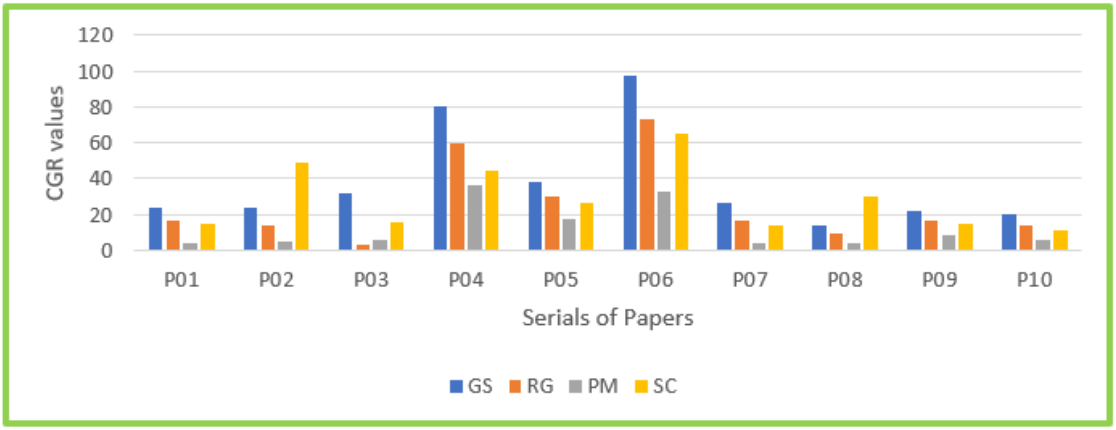


**Figure 2:** Showing comparison between CGE values in GS, RG, PM and SC.

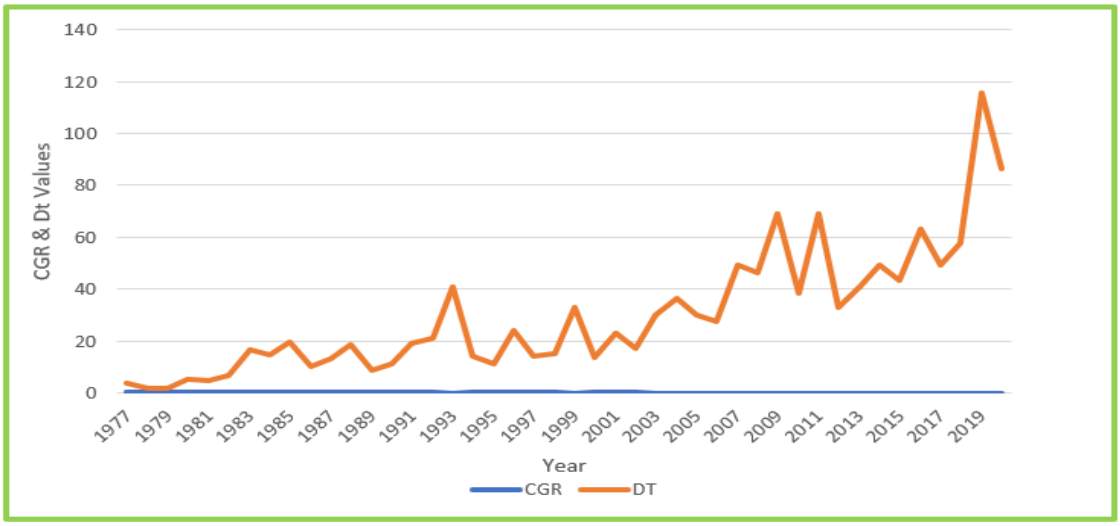


**Figure 3:** Showing relationship through line graph between CGR and Dt.

## Rank wise Closest Collaborators

As shown in Table 6, Dr. Ian Frazer collaborated with a vast network of 3,102 co-authors throughout his career. His most frequent collaborator was *G.J. Leggatt*, with whom he co-authored 79 papers over 26 years. *Germain J.P. Fernando* ranked second, contributing to 60 papers in 28 years. *Robert W. Tindle and Jian Zhou* followed, with 38 and 35 papers, respectively. Notably, *Jian Zhou* co-developed the HPV vaccine alongside Dr. Frazer, marking one of the most influential partnerships in his career. Other highly productive collaborators include *I.R. Mackay* (32 papers), *Janin Chandra* (30), *James W. Wells* (29), *Paul F. Lambert (22), Kong-Nan Zhao* (19), and *Zewen Kelvin Tuong* (19), spanning collaborative durations of 6 to 31 years. These co-authorship patterns reflect Dr. Frazer's extensive and sustained collaboration with leading figures in biomedical science.

## Co-authors and Validation of Lotka's Law

According to Lotka's Law of scientific productivity, approximately 60% of authors are expected to contribute a single publication, while smaller proportions contribute multiple works. Specifically, 15% should publish two papers (i.e. $1/2^2$ x 60), 7% should publish three papers (i.e. $1/3^2$ x 60), and so on, with diminishing percentages as the number of publications increases (Hertzel, n.d.). In the case of Dr. Ian Frazer, there are 1671 observed co-authors in the Table 6, of which 1332 co-authors (5.63%) are associated with single paper, 225 co-authors (12.77%) have two papers each, 77 co-authors (4.37%) are concerned with three articles each, 40 co-authors (2.27%) are belonged to 4 articles each, 26 co-authors (1.47%) have 5 articles each, and so on. This observed pattern closely approximates Lotka's Law, confirming that the majority of authors contributed to only one publication, with significantly fewer contributing to multiple works-a distribution characteristic of collaborative scientific research.

## Preferred Communication Channels and Related Indicators

Table 7 categorises 268 communication channels for 573 publications into eleven groups namely journal articles, conference proceedings, book chapters, books, research reports, patents, preprints, letters, erratum and corrections, audio documents and category not identified. Out of which, maximum are journals that is nearly 77%. His 4.53% articles were published in *Virology*, 2.79% each in *Medical Journal of Australia, Vaccine, and The* Journal of Immunology, 2.44% each in *PLoS (Public Library of Science) ONE, and Journal of Investigative Dermatology*, 2.09% in *Immunology and Cell biology*, 1.91% each in *European Journal of Immunology, and Journal of Virology*, and so on.

## Publication Concentration (PC)

PC = *(Number of channels containing half of total papers published / Total number of channels) x 100.* Here, half of total papers is 573 /2 = 286.5 or nearly 287 papers which are published in 51channes (journals) out of total 268 communication channels. So, PC = (51/268) x 100 = 19.03.

## Publication Density (PD)

PD = Total number of Papers / total number of channels used = 573/268 = 2.1 (nearly).

## Bradford's Law

According to the law, the 268 communication channels (listed in Table 7) used for disseminating Dr. Ian Frazer's 573 publications were divided into three distinct zones and each zone have nearly 33% of total publications. The first zone consists of 17 journals, which accounted for 191 papers (33.33%), while the second zone, consisting of 112 journals, covered 190 papers (33.16%). The third zone includes 139 other channels, including 58 journals, 38

**Table 1:** Year-wise and age-wise publications, 1977-2024.

| Year | TP | CmP | ABA b. 1953 | PPA | SAP | MAP | DC= MAP/TP |
|---|---|---|---|---|---|---|---|
| 1977 | 1 | 1 | 24 | 1 | | 1 | 1.00 |
| 1980 | 1 | 2 | 27 | 4 | | 1 | 1.00 |
| 1981 | 1 | 3 | 28 | 5 | 1 | | 0.00 |
| 1982 | 4 | 7 | 29 | 6 | | 4 | 1.00 |
| 1983 | 9 | 16 | 30 | 7 | | 9 | 1.00 |
| 1984 | 6 | 22 | 31 | 8 | | 6 | 1.00 |
| 1985 | 9 | 31 | 32 | 9 | | 9 | 1.00 |
| 1986 | 8 | 39 | 33 | 10 | | 8 | 1.00 |
| 1987 | 4 | 43 | 34 | 11 | 1 | 3 | 0.75 |
| 1988 | 5 | 48 | 35 | 12 | | 5 | 1.00 |
| 1989 | 4 | 52 | 36 | 13 | | 4 | 1.00 |
| 1990 | 9 | 61 | 37 | 14 | | 9 | 1.00 |
| 1991 | 8 | 69 | 38 | 15 | | 8 | 1.00 |
| 1992 | 6 | 75 | 39 | 16 | | 6 | 1.00 |
| 1993 | 15 | 90 | 40 | 17 | 2 | 13 | 0.87 |
| 1994 | 14 | 104 | 41 | 18 | 1 | 13 | 0.93 |
| 1995 | 9 | 113 | 42 | 19 | | 9 | 1.00 |
| 1996 | 9 | 122 | 43 | 20 | 2 | 7 | 0.78 |
| 1997 | 5 | 127 | 44 | 21 | 1 | 4 | 0.80 |
| 1998 | 15 | 142 | 45 | 22 | 2 | 13 | 0.87 |
| 1999 | 22 | 164 | 46 | 23 | 1 | 21 | 0.95 |
| 2000 | 11 | 175 | 47 | 24 | | 11 | 1.00 |
| 2001 | 21 | 196 | 48 | 25 | 1 | 20 | 0.95 |
| 2002 | 22 | 218 | 49 | 26 | 4 | 18 | 0.82 |
| 2003 | 11 | 229 | 50 | 27 | | 11 | 1.00 |
| 2004 | 28 | 257 | 51 | 28 | 6 | 22 | 0.78 |
| 2005 | 18 | 275 | 52 | 29 | | 18 | 1.00 |
| 2006 | 21 | 296 | 53 | 30 | 9 | 12 | 0.57 |
| 2007 | 22 | 318 | 54 | 31 | 9 | 13 | 0.59 |
| 2008 | 14 | 332 | 55 | 32 | 4 | 10 | 0.71 |
| 2009 | 18 | 350 | 56 | 33 | 6 | 12 | 0.67 |
| 2010 | 21 | 371 | 57 | 34 | 5 | 16 | 0.76 |
| 2011 | 12 | 383 | 58 | 35 | 1 | 11 | 0.92 |
| 2012 | 14 | 397 | 59 | 36 | 2 | 12 | 0.86 |
| 2013 | 9 | 406 | 60 | 37 | 1 | 8 | 0.87 |
| 2014 | 17 | 423 | 61 | 38 | 3 | 14 | 0.82 |
| 2015 | 10 | 433 | 62 | 39 | 3 | 7 | 0.70 |
| 2016 | 21 | 454 | 63 | 40 | 2 | 19 | 0.90 |
| 2017 | 19 | 473 | 64 | 41 | 1 | 18 | 0.95 |
| 2018 | 15 | 488 | 65 | 42 | 2 | 13 | 0.87 |
| 2019 | 18 | 506 | 66 | 43 | 1 | 17 | 0.94 |
| 2020 | 13 | 519 | 67 | 44 | 2 | 11 | 0.85 |
| 2021 | 18 | 537 | 68 | 45 | | 18 | 1.00 |
| 2022 | 14 | 551 | 69 | 46 | | 14 | 1.00 |
| 2023 | 8 | 559 | 70 | 47 | | 8 | 1.00 |
| 2024 | 10 | 569 | 71 | 48 | | 10 | 1.00 |
| n.d. | 4 | 573 | | | 3 | 1 | 0.25 |
| | 573 | | | | 76 | 497 | 0.87 |

**Table 2:** Publications by quinquennium and peak period of productivity.

| Quinquennium (5 years) | ABA (b. 1953) | PPA | APC | %-age | P/Y |
|---|---|---|---|---|---|
| 1977-1981 | 24-28 | 1-5 | 3 | 0.53 | 0.60 |
| 1982-1986 | 29-33 | 6-10 | 36 | 6.28 | 7.20 |
| 1987-1991 | 34-38 | 11-15 | 30 | 5.24 | 6.00 |
| 1992-1996 | 39-43 | 16-20 | 53 | 9.25 | 10.60 |
| 1997-2001 | 49-53 | 21-25 | 74 | 12.92 | 14.80 |
| 2002-2006 | 54-58 | 26-30 | 100 | 17.45 | 20.00 |
| 2007-2011 | 59-63 | 31-35 | 87 | 15.18 | 17.40 |
| 2012-2016 | 64-68 | 36-40 | 71 | 12.39 | 14.20 |
| 2017-2021 | 69-73 | 41-45 | 83 | 14.48 | 16.60 |
| 2022-2026 | 74-76 | 46-50 | 32 | 5.59 | 6.40 |
| Total | | | 569 | 99.31 | |
| No Date | | | 4 | 0.69 | |
| Grand Total | | | 573 | 100 | |

conference proceedings, 18 book chapters, 3 books, 5 research reports, 4 patents, 4 erratum and corrections, 2 preprints, 2 letters, 1 audio document, and 4 unidentified sources, which together contributed 192 papers (33.51%). By this, it is found that the relationship of each zone in the present study follows Bradford's Law.

## Publications by Country

Of Dr. Ian Frazer's total of 573 publications, the majority were produced in the USA, with 286 papers (50.44%) originating there. The UK follows with 104 papers (18.16%), and Australia contributes 80 papers (13.96%). Other notable contributions include 38 papers (6.64%) from the Netherlands, 24 papers (4.19%) from Germany, and 11 papers (1.93%) from Switzerland.

**Table 3:** Authorship pattern and time span.

| Patterns | Single | | Two | Three | Four | Five | Six | Seven | Eight | Nine | Ten | | MTT | TP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-collaborative papers | 74 | 3 | | | | | | | | | | | | 77 |
| Collaborative papers | | | 67 | 46 | 66 | 71 | 59 | 44 | 23 | 32 | 11 | 1 | 76 | 496 |
| Time Span | 39 | 0 | 39 | 46 | 38 | 41 | 41 | 40 | 35 | 39 | 24 | 1 | 31 | |
| Year-Rages | 1981-2020 | n.d. to n.d. | 1982-2021 | 1977-2023 | 1983-2021 | 1982-2023 | 1983-2024 | 1983-2023 | 1985-2020 | 1985-2024 | 1998-2022 | n.d. | 1993-2024 | |

**Table 4:** Authorship pattern with CC, CI, MCC. Check the table.

| Year | TP | CmP | Authorship Pattern | | | | | | | | | | CoA | TA | CC | CI | MCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Single | Multiple Authorship | | | | | | | | | | | | | |
| | | | | 2A | 3A | 4A | 5A | 6A | 7A | 8A | 9A | 10A | <10A | | | | | |
| 1977 | 1 | 1 | | | 1 | | | | | | | | | 2 | 3 | 0.67 | 3.00 | 0.00 |
| 1980 | 1 | 2 | | | | | 1 | | | | | | | 4 | 5 | 0.80 | 5.00 | 0.00 |
| 1981 | 1 | 3 | 1 | | | | | | | | | | | | 1 | 0.00 | 0.00 | 0.00 |
| 1982 | 4 | 7 | | 1 | 2 | | 1 | | | | | | | 9 | 13 | 0.66 | 3.25 | 0.88 |
| 1983 | 9 | 16 | | 2 | 3 | 1 | | 1 | 2 | | | | | 28 | 37 | 0.70 | 4.11 | 0.78 |
| 1984 | 6 | 22 | | 3 | 2 | 1 | | | | | | | | 10 | 16 | 0.64 | 2.67 | 0.76 |
| 1985 | 9 | 31 | | 2 | | 1 | 2 | 1 | | 1 | 2 | | | 41 | 50 | 0.76 | 5.56 | 0.85 |
| 1986 | 8 | 39 | | 1 | 1 | 2 | 3 | | | 1 | | | | 28 | 36 | 0.74 | 4.50 | 0.84 |
| 1987 | 4 | 43 | 1 | | | 1 | 2 | | | | | | | 11 | 15 | 0.59 | 3.75 | 0.73 |
| 1988 | 5 | 48 | | 1 | 1 | 2 | 1 | | | | | | | 13 | 18 | 0.69 | 3.60 | 0.86 |
| 1989 | 4 | 52 | | | | 3 | 1 | | | | | | | 13 | 17 | 0.76 | 4.25 | 1.01 |
| 1990 | 9 | 61 | | 1 | 1 | 4 | 2 | 1 | | | | | | 28 | 37 | 0.73 | 4.11 | 0.82 |
| 1991 | 8 | 69 | | 2 | 1 | 3 | | 2 | | | | | | 23 | 31 | 0.70 | 3.87 | 0.79 |
| 1992 | 6 | 75 | | | | 1 | 3 | 1 | 1 | | | | | 26 | 32 | 0.81 | 5.34 | 0.97 |
| 1993 | 15 | 90 | 2 | 1 | 2 | 4 | 3 | 2 | | | | | 1 | 69 | 84 | 0.66 | 5.60 | 0.71 |
| 1994 | 14 | 104 | 1 | 1 | | 1 | 3 | 1 | 4 | | 1 | | 2 | 78 | 92 | 0.76 | 6.57 | 0.81 |
| 1995 | 9 | 113 | | 1 | 1 | | 3 | 2 | | 1 | 1 | | | 40 | 49 | 0.78 | 5.45 | 0.87 |
| 1996 | 9 | 122 | 2 | 1 | | 2 | | | 3 | | | | 1 | 36 | 45 | 0.61 | 5.00 | 0.68 |
| 1997 | 5 | 127 | 1 | | | | | 2 | | 1 | | | 1 | 31 | 36 | 0.69 | 7.20 | 0.86 |
| 1998 | 15 | 142 | 2 | 1 | 1 | 6 | 2 | | | 2 | | 1 | | 52 | 67 | 0.66 | 4.47 | 0.71 |
| 1999 | 22 | 164 | 1 | 4 | 2 | 4 | 6 | 1 | 2 | 1 | | | 1 | 78 | 100 | 0.71 | 4.54 | 0.73 |
| 2000 | 11 | 175 | | 2 | 1 | 1 | 2 | | 3 | | | | 2 | 53 | 64 | 0.76 | 5.82 | 0.83 |
| 2001 | 21 | 196 | 1 | 1 | 2 | 4 | | 5 | 1 | 2 | 3 | | 2 | 107 | 128 | 0.77 | 6.09 | 0.81 |
| 2002 | 22 | 218 | 4 | 5 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | | 1 | 87 | 109 | 0.59 | 4.95 | 0.61 |
| 2003 | 11 | 229 | | 1 | 2 | 1 | 3 | 1 | | 2 | | | 1 | 56 | 67 | 0.77 | 6.09 | 0.84 |
| 2004 | 28 | 257 | 7 | 2 | 1 | 2 | | 7 | 2 | 1 | 2 | 1 | 3 | 131 | 159 | 0.61 | 5.67 | 0.63 |
| 2005 | 18 | 275 | | 2 | 4 | 3 | 2 | 3 | 2 | | 1 | | 1 | 73 | 91 | 0.75 | 5.05 | 0.78 |
| 2006 | 21 | 296 | 9 | 6 | 2 | | | | 2 | 1 | 1 | | | 37 | 58 | 0.37 | 2.76 | 0.38 |
| 2007 | 22 | 318 | 9 | 5 | 3 | | 2 | 1 | 2 | | | | | 36 | 58 | 0.39 | 2.64 | 0.41 |
| 2008 | 14 | 332 | 4 | 3 | 3 | | 1 | 2 | | | | | 1 | 35 | 49 | 0.49 | 3.50 | 0.52 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 18 | 350 | 6 | 2 | 2 | | 1 | 1 | 1 | 1 | 1 | | 3 | 88 | 106 | 0.52 | 5.89 | 0.54 |
| 2010 | 21 | 371 | 5 | 4 | | | 6 | 2 | | | 2 | | 2 | 94 | 115 | 0.58 | 5.47 | 0.61 |
| 2011 | 12 | 383 | 1 | 2 | 2 | 1 | 2 | | 1 | | | | 3 | 214 | 226 | 0.70 | 18.83 | 0.76 |
| 2012 | 14 | 397 | 2 | 1 | | 1 | 1 | 3 | 2 | | 3 | | 1 | 69 | 83 | 0.71 | 5.93 | 0.75 |
| 2013 | 9 | 406 | 1 | | | 1 | 1 | 3 | | 1 | 2 | | | 45 | 54 | 0.74 | 6.00 | 0.83 |
| 2014 | 17 | 423 | 3 | | | 4 | 1 | 3 | 1 | | 4 | | 1 | 79 | 96 | 0.68 | 5.64 | 0.72 |
| 2015 | 10 | 433 | 3 | | | 1 | 1 | 1 | 1 | | 1 | | 2 | 141 | 151 | 0.61 | 15.10 | 0.67 |
| 2016 | 21 | 454 | 2 | 2 | | 3 | 5 | 1 | 4 | 2 | 1 | | 1 | 92 | 113 | 0.72 | 5.38 | 0.75 |
| 2017 | 19 | 437 | 1 | 4 | | 3 | 3 | 1 | | 2 | 1 | | 4 | 121 | 140 | 0.73 | 7.36 | 0.76 |
| 2018 | 15 | 488 | 2 | | 1 | | | 3 | 1 | 1 | 1 | | 6 | 152 | 167 | 0.76 | 11.13 | 0.81 |
| 2019 | 18 | 506 | 1 | 1 | 1 | 1 | | 3 | 3 | 1 | | | 7 | 156 | 174 | 0.81 | 9.67 | 0.85 |
| 2020 | 13 | 519 | 2 | 1 | | | 1 | 1 | | 1 | | 4 | 3 | 108 | 121 | 0.73 | 9.31 | 0.78 |
| 2021 | 18 | 537 | | 1 | 1 | 2 | 1 | 1 | 2 | | | 2 | 8 | 151 | 169 | 0.85 | 9.38 | 0.89 |
| 2022 | 14 | 552 | | | | | 2 | | 1 | | 1 | 3 | 7 | 136 | 150 | 0.93 | 10.71 | 0.99 |
| 2023 | 8 | 559 | | | 1 | | 1 | | 1 | | 1 | | 4 | 67 | 75 | 0.87 | 9.37 | 0.99 |
| 2024 | 10 | 569 | | | | | | 1 | | | 2 | | 7 | 145 | 155 | 0.92 | 15.50 | 1.02 |
| Total | | 469 | 74 | | 46 | 66 | 71 | 59 | 44 | 23 | 32 | 11 | 76 | 3093 | 3662 | 0.68 | 6.41 | 0.68 |
| n.d. | 4 | 573 | 3 | | | | | | | | | 1 | | 9 | 13 | | | |
| GT | 573 | | 77 | 67 | 46 | 66 | 71 | 59 | 44 | 23 | 32 | 12 | 76 | 3102 | 3675 | 0.68 | 6.41 | 0.68 |

A smaller proportion of publications come from countries such as China (9 papers), India (3 papers), and France (2 papers), among others. Additionally, single papers were contributed from Brazil, Canada, Italy, Japan, Portugal, and Austria. The origin of five papers remains undetermined.

## Top 10 Highly Cited Scholar Articles

Table 8 presents a citation analysis of Dr. Frazer's top 10 most-cited papers, based on data from four citation databases: Google Scholar (GS), ResearchGate (RG), PubMed (PM), and Scopus (SC). His most highly cited paper, *"Identification of the alpha6 integrin as a candidate receptor for papillomaviruses,"* received 1325 citations in SC, 638 in GS, 377 in RG, and 134 in PM. Another notable work, *"Expression of vaccinia recombinant HPV 16 L1 and L2 ORF proteins in epithelial cells is sufficient for assembly of HPV virion-like particles,"* received 775 citations in GS, 486 in SC, 540 in RG, and 123 in PM. Among all sources, the highest number of total citations was recorded in the GS database. The highest Citation Growth Rate (CGR), 97.8, was observed in GS for the paper *"The projected timeframe until cervical cancer elimination in Australia: a modelling study"* at five years of age. This was followed by CGR values of 73 in RG, 65.4 in SC, and 33 in PM. Another paper, *"Interferon-γ derived from cytotoxic lymphocytes directly enhances their motility and cytotoxicity,"* showed a CGR of 80.85 in GS after seven years, followed by 59.28 in RG and 44.42 in SC. Overall, CGR values for his top papers ranged from 3 to 97. Figure 2 draws a bar diagrams showing comparison between CGR values in GS, RG, PM and SC.

## Relative Growth Rate (ReGR) and Doubling Times (Dt)

### *Relative Growth Rate (ReGR)*

ReGR is the increase in the number of publications/ papers over the specific period of interval. According to formula of Mahapatra (1985), ReGR can be calculated as below.

ReGR = W2 - W1 / T2 - T1

Where, ReGR = Relative Growth Rate over the specific period of the interval.

$W_{1 =}$ Natural logarithm of the initial number of publications = $Log_e$ 1.

$W_2$ = Natural logarithm of the final number of publications = $\log_e$ 2.

$T_{1 =}$ Unit of initial time.

$T_2$ = Unit of final time.

For this study, $T_2$ - $T_1$ = the time difference in units between start and end times = 1 year only.

**Table 5: Status in byline of authors.**

| Authorship pattern | Status in byline of authors | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | More than 10th positions | Total |
| 2-authored | 33 | 34 | | | | | | | | | | 67 |
| 3-authored | 13 | 11 | 22 | | | | | | | | | 46 |
| 4-authored | 8 | 7 | 15 | 36 | | | | | | | | 66 |
| 5-authored | 6 | 8 | 11 | 17 | 29 | | | | | | | 71 |
| 6-authored | 2 | 2 | 5 | 7 | 21 | 22 | | | | | | 59 |
| 7-authored | 1 | 1 | | 3 | 11 | 18 | 10 | | | | | 44 |
| 8-authored | 4 | | 2 | 2 | 2 | 3 | 6 | 4 | | | | 23 |
| 9-authored | 4 | 3 | | | 4 | 1 | 6 | 10 | 4 | | | 32 |
| 10-authored | | | | | | | 2 | 5 | 2 | 3 | | 12 |
| 11-authored | 1 | | | | 1 | | | 2 | 2 | 4 | 4 | 14 |
| 12-authored | | | | 1 | | 1 | | | 2 | 5 | 6 | 15 |
| 13-authored | | | | 1 | | 1 | | 1 | | 1 | 4 | 8 |
| 14-authored | | | 1 | | | | | | | 1 | | 2 |
| 15-authored | | | | 1 | | 1 | 1 | | 1 | | 5 | 9 |
| 16-authored | 1 | | | | | | | | | | 2 | 3 |
| 17-authored | 1 | | | | | | | 1 | | | 1 | 3 |
| 18-authored | 1 | | | | | | | | | | 3 | 4 |
| 19-authored | | | | | | | | | | | 2 | 2 |
| 20-authored | | | | | | | | | | | 2 | 2 |
| 22-authored | | | | | | | | | | 1 | 1 | 2 |
| 23-authored | | | | | | | | | | | 1 | 1 |
| 28-authored | | | | | | | | | | | 1 | 1 |
| 29-authored | | | | | | | | | | | 1 | 1 |
| 30-authored | | | | | | | | | | | 1 | 1 |
| 31-authored | | | | | | 1 | | | | | 2 | 3 |
| 34-authored | | | | | | | | | | | 1 | 1 |
| 42-authored | | | | | | | | | | | 1 | 1 |
| 58-authored | | | | | | | | | | | 1 | 1 |
| 59-authored | | | | | | | | | | | 1 | 1 |
| 163-authored | | | | | | | | | | | 1 | 1 |
| Total | 75 | 66 | 56 | 68 | 68 | 48 | 25 | 23 | 11 | 15 | 41 | 496 |

## Doubling Time (Dt)

Doubling time means how many times required just to make double the existing number of publications with a given Relative Growth Rate (ReGR). It can be measured by;

Dt = 0.693/ ReGR

Where 0.693 is a standard natural logarithm of 2.

Table 9 outlines the calculated values of ReGR (Relative Growth Rate) and Dt (Doubling Time) for the years 1977 to 2024. The data indicates that ReGR was notably high from 1981 to 1986, after which it fluctuated over the years, with a general downward trend that culminated at 0.008 in 2024. For Doubling Time, the value was 3.937 in 1981, followed by a period of fluctuation through 1982 to 2022. It peaked at 115.5 in 2023, before reducing to **86.625** in **2024.** The **ReGR** and **Dt** for the last four papers could not be determined due to indeterminate publication dates. Figure

**Table 6: Leading collaborators.**

| Paper by each author | Name of Collaborators | Total Co-authors | YFP | YLP | Time span | P/Y |
|---|---|---|---|---|---|---|
| 79 | G. J. Leggatt | 79 | 1998 | 2024 | 26 | 3.03 |
| 60 | Germain JP Fernando | 60 | 1991 | 2019 | 28 | 2.14 |
| 38 | Robert W Tindle | 38 | 1990 | 2003 | 13 | 2.93 |
| 35 | Jian Zhou | 35 | 1999 | 2011 | 12 | 2.92 |
| 1 | IR Mackay | 32 | 1982 | 1999 | 17 | 1.82 |
| 30 | Janin Chandra | 30 | 2016 | 2024 | 8 | 3.75 |
| 29 | James W Wells | 29 | 1993 | 2024 | 31 | 0.94 |
| 22 | Paul F Lambert | 22 | 1994 | 2016 | 22 | 1.00 |
| 20 | Kong-Nan Zhao | 20 | 1998 | 2010 | 12 | 1.67 |
| 19 | Zewen Kelvin Tuong | 19 | 2016 | 2022 | 6 | 3.17 |
| 18 | Rachel L de Kluyver; Jazmina Gonazlez-Cruz [02] | 36 | | | 9, 8 | 2.00, 2.25 |
| 15 | Ranjeny Thomas; H Peter Soyer [02] | 30 | | | 11, 9 | 1.36, 1.67 |
| 13 | Nicholas A Saunders; SR Mattarollo; Wen Jun Liu [03] | 39 | | | 22, 8, 4 | 0.59, 1.63, 3.25 |
| 12 | Mark AF Kendall; Raymond J Steptoe; X Liu; Nicholas G Martin [04] | 48 | | | 10, 7, 21, 12 | 1.2, 1.71, 0.57, ‘1.00 |
| 11 | David M Evans; L Kennedy [02] | 22 | | | 12, 30 | 0.92, 0.37 |
| 9 | Fiona Simpson; Quan H Nguyen; XY Sun; Siok M Teoh [04] | 36 | | | 7, 6, 8, 6 | 1.2, 1.5, 1.12, 1.5 |
| 8 | Kai Dun Tang; Karen Herd; LA Selvey; Rahul Ladwa; XS Liu [05] | 40 | | | 6, 9, 8, 3, 11 | 1.33, 0.89, ‘1.00, 2.67, 0.72 |
| 7 | Ahmed M Mehdi; Benedict J Panizza; Chamindie Punyadeera; Jennifer Anne Bridge; LA Dunn; Nana Haahr Overgaard; Rohit Sinha; XianFeng Chen; Xiaosong Liu; Yan Xu [10] | 70 | | | 3, 4, 7, 5, 10, 4, 8, 3, 18, 22 | 2.33, 1.75, 1, 1.4, 0.7, 1.75, 0.87, 2.33, 0.38, 0.32 |
| 6 | Amy Liem; Annika Krueger; Christine Gosmann; Chris JLM Meijer; Douglas R Lowy; Eduardo LF Franco; Grant W Montgomery; J Pang; J Zhong; K Hengst; Lynn K Tolley; P Kuo; Philip Hugenholtz; Samuel W Lukowski; Sandro V Porceddu; Suzann M Garland; Tarl W Prow; Vithagna Khammanivong; Trina J Stewarte [19, 1.09%] | 114 | | | 15, 5, 3, 18, 13, 24, 5, 8, 4, 4, 7, 2, 3, 6, 5, 3, 8, 3, 6. | 0.4, 1.2, 2, 0.34, 0.46, 0.25, 1.2, 0.75, 0.5, 1.5, 1.5, 0.85, 3, 1, 1.2, 2, 0.75, 2, 1 |
| 5 | A Blumenthal; AS Bergot; Bo Li; Chenhao Zhou; Christopher Perry; D Perinet; Fang Zhou; G Zhu; Guoying Ni; IJ Kronborg; Lorena E Brown; M Little; Manuel AR Ferreira; Margaret Louise McGrath; Mark Morrison; Michael L Crichton; Michael S Roberts; NX Fang; O Vennemann; P Hogan; Richard Linedale; RM Crapper; S Mattarollo; Tianfang Wang; Wai-Ping Woo; Ying Mei Qi [26, 1.47%] | 130 | | | 1, 6, 9, 3, 7, 3, 6, 6, 3, 1, 3, 1, 2, 1, 4, 5, 15, 8, 3, 7, 3 1,7, 2, 11, 4. | 5, 0.83, 0.56, 1.67, 0.71, 1.67, 0.83, 0.83, 1.67, 5, 1.6, 5, 2.5, 5, 1.25, 1, 0.34, 0.62, 1.67, 0.71, 0.16, 0.71, 2.5, 0.45, 1.25 |
| 4 | 40 authors with 4 paper each [2.27%] | 160 | | | | |
| 3 | 77 authors with 3 papers each [4.37%] | 231 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 225 authors with 2 papers each [12.77%] | 450 | | | | |
| 1 | 1332 authors with 1 each [75.63%] | 1332 | | | | |
| | 1761 Co-authors (Individual name wise) | 3102 | | | | |

**Table 7: Preferred communication channels.**

| Sl. No. | Name of Channels | TP | YFP | YLP | Country |
|---|---|---|---|---|---|
| **Gr. I** | **Journal Articles (439, 76.62%)** | | | | |
| 1 | Virology | 26 | 1991 | 2019 | USA |
| 2 | Medical Journal of Australia | 16 | 1983 | 2012 | Australia |
| 3 | Vaccine | 16 | 1995 | 2021 | USA |
| 4 | The Journal of Immunology | 16 | 1998 | 2021 | USA |
| 5 | PLoS (Public Library of Science) ONE | 14 | 2010 | 2019 | USA |
| 6 | Journal of Investigative Dermatology | 14 | 2004 | 2021 | USA |
| 7 | Immunology and Cell biology | 12 | 1990 | 2017 | Australia |
| 8 | European Journal of Immunology | 11 | 1998 | 2016 | Germany |
| 9 | Journal of Virology | 11 | 1994 | 2015 | USA |
| 10 | Cancer Research | 8 | 1994 | 2016 | UK |
| 11 | Cancers | 8 | 1995 | 2022 | USA |
| 12 | Cancer Forum: Official journal of the Clinical Oncological Society of Australia. | 7 | 2002 | 2008 | Australia |
| 13 | Pathology: The Journal of Royal College of Pathologists of Australia) | 7 | 1985 | 2016 | Australia |
| 14 | Tissue Antigens | 7 | 2005 | 2005 | USA |
| 15 | Clinical and Experimental Immunology | 6 | 1983 | 1999 | UK |
| 16 | Gynecologic Oncology | 6 | 2004 | 2019 | USA |
| 17 | Journal of Controlled Release | 6 | 2009 | 2014 | Netherlands |
| 18 | Journal of Leukocyte Biology | 6 | 1993 | 2017 | USA |
| 19 | Frontiers in Immunology | 5 | 2017 | 2022 | UK |
| 20 | The Lancet | 5 | 1983 | 2006 | UK |
| 21 | Virus Research | 5 | 1995 | 2003 | Netherlands |
| 22 | Experimental Dermatology | 4 | 2009 | 2018 | USA |
| 23 | Journal of Clinical and Laboratory Immunology | 4 | 1982 | 1984 | Germany |
| 24 | Papillomavirus Research | 4 | 2017 | 2019 | Netherlands |
| 25 | International Journal of Cancer | 3 | 2004 | 2016 | USA |
| 26 | Arthritis and Rheumatism: Official Journal of the American College of Rheumatology | 3 | 1988 | 1998 | USA |
| 27 | Australian and New Zealand Journal of Medicine | 3 | 1983 | 1989 | Australia |
| 28 | Cell | 3 | 2018 | 2023 | USA |
| 29 | Clinical Immunology and Immunopathology | 3 | 1982 | 1985 | Netherlands |
| 30 | Frontiers in Oncology | 3 | 2019 | 2024 | Switzerland |
| 31 | Journal of General Virology | 3 | 1990 | 1994 | UK |
| 32 | Journal of the National Cancer Institute | 3 | 2001 | 2004 | UK |
| 33 | Sexually Transmitted Infections | 3 | 1996 | 2015 | UK |

| | | | | | |
|---|---|---|---|---|---|
| 34 | Vaccines Against Virally Induced Cancers | 3 | 1994 | 1994 | Australia |
| 35 | Australian and New Zealand Journal of Obstetrics and Gynaecology | 2 | 1990 | 1993 | Australia |
| 36 | Asia-Pacific Journal of Clinical Oncology | 2 | 2020 | 2024 | Australia |
| 37 | British Medical Journal | 2 | 1977 | 1980 | UK |
| 38 | Cancer Immunology Research | 2 | 2016 | 2016+ | USA |
| 39 | Clinical and Translational Immunology | 2 | 2021 | 2024 | Australia |
| 40 | Current opinion in immunology | 2 | 1996 | 2007 | USA |
| 41 | Hepatology | 2 | 1982 | 1987 | USA |
| 42 | Human Vaccines and Immunotherapeutics | 2 | 2012 | 2016 | UK |
| 43 | Immunological Reviews | 2 | 1999 | 2011 | USA |
| 44 | Infectious Diseases in Obstetrics and Gynecology | 2 | 2006 | 2006 | USA |
| 45 | International Journal of Gynecological Cancer | 2 | 2006 | 2021 | USA |
| 46 | International Journal of Gynecology and Obstetrics | 2 | 2006 | 2006 | USA |
| 47 | Intervirology | 2 | 1999 | 2000 | Germany |
| 48 | Iscience | 2 | 2021 | 2021 | Netherlands |
| 49 | Journal for Immunotherapy of Cancer | 2 | 2023 | 2024 | UK |
| 50 | Journal of Immunological Methods | 2 | 1983 | 1990 | Netherlands |
| 51 | Journal of Medical Genetics | 2 | 2006 | 2007 | UK |
| 52 | Journal of Virological Methods | 2 | 1992 | 1993 | Netherlands |
| 53 | Nucleic Acids Research | 2 | 2004 | 2007 | UK |
| 54 | Oil and Gas Journal | 2 | 1992 | 2002 | USA |
| 55 | Oncoimmunology | 2 | 2015 | 2018 | USA |
| 56 | Oncotarget | 2 | 2017 | 2017 | India |
| 57 | PLoS Pathogens | 2 | 2014 | 2016 | USA |
| 58 | Proceedings of the National Academy of Sciences | 2 | 1991 | 2021 | USA |
| 59 | Scientific Reports | 2 | 2019 | 2022 | UK |
| 60 | The American Journal of Human Genetics | 2 | 2009 | 2010 | USA |
| 61 | The Annals of Thoracic Surgery | 2 | 1994 | 1998 | Netherlands |
| 62 | The Innovation | 2 | 2020 | 2020 | China |
| 63 | The Lancet Public Health | 2 | 2018 | 2019 | UK |
| 64 | Viral Immunology | 2 | 1999 | 2018 | USA |
| 65 | Lancet Oncology | 2 | 2009 | 2010 | UK |
| 66 | Immunology and Infections Diseases | 2 | 1990 | 1992 | USA |
| 67-187 | 121 Journals with 1 paper each | 121 | | | |
| **Gr.2.** | **Conference Proceedings (51, 8.90%)** | | | | |
| 188 | Paper presented at the Offshore Technology Conference, Houston, Texas, April 2001 | 10 | 1998 | 2008 | USA |

| | | | | | |
|---|---|---|---|---|---|
| 189 | Keystone Symposia on Molecular and Cellular Biology, Keystone, CO United States, 16-23 January 1995. NEW YORK: Wiley-Blackwell. | 3 | 1994 | 1995 | USA |
| 190 | International Conference on Offshore Mechanics and Arctic Engineering 36134 … | 2 | 2002 | 2008 | USA |
| 191 | *International Congress of Immunology (ICI)*, Melbourne, Australia, 21-16 August 2016. Weinheim, Germany: Wiley. | 2 | 2016 | 2016 | Germany |
| 192- 225 | 34 other Conference papers @ 1 paper each | 34 | | | |
| **Gr. 3** | **Book Chapter (In Analytic Document) (22, 3.83%)** | | | | |
| 226 | New generation vaccines, 982-989, CRC Press; ByMyron M. Levine, Gordon Dougan, Michael F. Good, Gary J. Nabel, James P. Nataro, Rino Rappuoli | 3 | 2004 | 2016 | USA |
| 227 | Redefining the Pacific? Regionalism past, present and future. Edited by Jenny Bryant-Tokalau, Ian Frazer. Ashgate Publishing Ltd. USA | 3 | 2006 | 2017 | USA |
| 228 | Vaccines for Human Papillomavirus Infection and Anogenital Disease. (pp. 13-31); edited by Robert W. Tindle. Austin, USA: R. G. Landes Company. | 2 | 1999 | 1999 | USA |
| 229-242 | 14 other book chapters with 1 paper each | 14 | | | |
| **Gr. 4** | **Books (03, 0.53%)** | | | | |
| 243 | World Health Organization | 1 | 1999 | 1999 | Switzerland |
| 244 | Routledge, Taylor and Fancies Group | 1 | 2017 | 2017 | UK |
| 245 | Redefining the Pacific?: Regionalism, Past, Present and Future. Edited by Jenny Bryant-Tokalau, Ian Frazer. Ashgate Publishing Ltd. USA | 1 | 2006 | 2006 | USA |
| **Gr. 5** | **Research Report (06, 1.05%)** | | | | |
| 246 | Australasian Sleep Association | 1 | 2012 | 2012 | Australia |
| 247 | Australia: Australian Government | 1 | 2013 | 2013 | Australia |
| 248 | Australian Academy of Health and Medical Sciences | 1 | 2022 | 2022 | Australia |
| 249 | Commonwealth of Australia, Canberra, Australia, | 2 | 2005 | 2013 | Australia |
| 250 | The Australian Society for Medical Research | 1 | 2012 | 2012 | Australia |
| **Gr. 6** | **Patents (33, 5.76%)** | | | | |
| 251 | Australian Patent AUPK732291 | 1 | 1991 | 1991 | Australia |
| 252 | Patents WO 02/083181 A1 | 1 | 2002 | 2002 | Switzerland |
| 253 | Patent published. No. WO 2009/049351 A1. | 1 | 2009 | 2009 | Switzerland |
| 254 | US Patent | 30 | 1999 | 2020 | USA |
| **Gr.7** | **Preprint (06, 1.05%)** | | | | |
| 255 | bioRxiv: the preprint server for Biology | 5 | 2020 | 2024 | USA |
| 256 | Research Square (https://www.researchsquare.com/article/rs-73533/v1) | 1 | 2020 | 2020 | Unknown |
| **Gr. 8** | **Letters (02, 0.35%)** | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 257 | Untitled - Reply (Letter to editor, brief commentary or brief communication in Australian and New Zealand Journal of Obstetrics and Gynaecology on UQe-space) | 1 | 1993 | 1993 | Australia |
| 258 | To the editor (in Australian and New Zealand Journal of Obstetrics and Gynaecology on UQe-space) | 1 | 1993 | 1993 | Australia |
| **Gr. 9** | **Erratum and Corrections (04, 0.69%)** | | | | |
| 259 | Erratum:IL-10 Mediates Suppression of the CD8 T Cell IFN-γ Response to a Novel Viral Epitope in a Primed Host [Journal of Immunology (2003) 171] | 1 | 2004 | 2004 | USA |
| 260 | Erratum: Cervical cancer control, priorities and new directions [International Journal of Cancer (2003) 108] | 1 | 2004 | 2004 | USA |
| 261 | Correction: Defining the genetic susceptibility to cervical neoplasia-A genome-wide association study. [PLoS Genetics, 14 (3)] | 1 | 2018 | 2018 | USA |
| 262 | Correction: the kinematics of cytotoxic lymphocytes influence their ability to kill target cells. [PLoS One, 9 (6)] | 1 | 2014 | 2014 | USA |
| **Gr. 10** | **Audio Documents (01, 0.17%)** | | | | |
| 263 | Australian Broadcasting Corporation (2023-09-05) | 1 | 2023 | 2023 | Australia |
| **Gr. 11** | **Channel Not Identified (06, 1.05%)** | | | | |
| 264 | University of Salford | 1 | 1981 | 1981 | UK |
| 265 | University of Melbourne | 1 | 1987 | 1987 | Australia |
| 266 | Channel not Identified | 2 | n.d. | n.d. | Unknown |
| 267 | https://www.researchgate.net/profile/Germain-Fernando/publication/228512063 | 1 | n.d. | n.d. | Unknown |
| 268 | https://espace.library.uq.edu.au/data/UQ_184811/Thursday_FrazerPPT.pdf? (Diamantina Institute, The University of Queensland, Brisbane, Australia) | 1 | n.d. | n.d. | Australia |
| 268 | Total | 573 | | | |

**Table 8: Top 10 highly cited publications.**

| | Title of Papers | Publication Channels (Year) | Total Citation | | | | Rank | | | | AoP 2024 | CGR | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS | RG | PM | SC | GS | RG | PM | SC | | GS | RG | PM | SC |
| P01 | Expression of vaccinia recombinant HPV 16 L1 and L2 ORF proteins in epithelial cells is sufficient for assembly of HPV virion-like particles | Virology (1991) | 775 | 540 | 123 | 486 | 1 | 1 | 5 | 3 | 33 | 23.48 | 16.36 | 3.72 | 14.72 |
| P02 | Identification of the alpha6 integrin as a candidate receptor for papillomaviruses | Journal of Virology (1997) | 638 | 377 | 134 | 1325 | 2 | 4 | 4 | 1 | 27 | 23.62 | 13.96 | 4.96 | 49.07 |
| P03 | Prevention of cervical cancer through papillomavirus vaccination | Nature Reviews Immunology (2004) | 636 | 94 | 111 | 322 | 3 | 10 | 7 | 6 | 20 | 31.8 | 3.2 | 5.55 | 16.1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P04 | Interferon-γ derived from cytotoxic lymphocytes directly enhances their motility and cytotoxicity | Cell Death and Disease (2017) | 566 | 415 | 252 | 311 | 4 | 2 | 1 | 7 | 7 | 80.85 | 59.28 | 36 | 44.42 |
| P05 | New gene functions in megakaryopoiesis and platelet formation | Nature (2011) | 496 | 392 | 223 | 343 | 5 | 3 | 2 | 4 | 13 | 38.15 | 30.15 | 17.15 | 26.38 |
| P06 | The projected timeframe until cervical cancer elimination in Australia: a modelling study | The Lancet Public Health (2019) | 489 | 365 | 165 | 327 | 6 | 5 | 3 | 5 | 5 | 97.8 | 73 | 33 | 65.4 |
| P07 | Prophylactic HPV vaccines: underlying mechanisms | Vaccine (2006) | 476 | 295 | 76 | 254 | 7 | 6 | 10 | 8 | 18 | 26.44 | 16.38 | 4.22 | 14.11 |
| P08 | Papillomavirus capsid protein expression level depends on the match between codon usage and tRNA availability | Journal of Virology (1999) | 357 | 237 | 104 | 747 | 8 | 8 | 8 | 2 | 25 | 14.28 | 9.48 | 4.16 | 29.88 |
| P09 | Common variants in TMPRSS6 are associated with iron status and erythrocyte volume | Nature genetics (2009) | 330 | 244 | 121 | 215 | 9 | 7 | 6 | 9 | 15 | 22 | 16.27 | 8.07 | 14.33 |
| P10 | Interaction of human papillomaviruses with the host immune system: a well evolved relationship | Virology (2009) | 297 | 204 | 83 | 169 | 10 | 9 | 9 | 10 | 15 | 19.8 | 13.6 | 5.53 | 11.27 |

**Table 9: Relative growth rate and doubling time.**

| S. No. | Years | Publications | CumPub. | W1 ($Log_e$ 1) | W2 ($log_e$ 2) | ReGR = W2-W1/$T_2$ - $T_1$ | Dt= 0.693/ReGR |
|---|---|---|---|---|---|---|---|
| 1 | 1977 | 1 | 1 | -- | 0.00 | -- | -- |
| 2 | 1978 | 0 | 1 | 0.00 | 0.00 | -- | -- |
| 3 | 1979 | 0 | 1 | 0.00 | 0.00 | -- | -- |
| 4 | 1980 | 1 | 2 | 0.00 | 0.301 | -- | -- |
| 5 | 1981 | 1 | 3 | 0.301 | 0.477 | 0.176 | 3.937 |
| 6 | 1982 | 4 | 7 | 0.477 | 0.845 | 0.368 | 1.883 |
| 7 | 1983 | 9 | 16 | 0.845 | 1.204 | 0.359 | 1.930 |
| 8 | 1984 | 6 | 22 | 1.204 | 1.342 | 0.138 | 5.021 |
| 9 | 1985 | 9 | 31 | 1.342 | 1.491 | 0.149 | 4.651 |
| 10 | 1986 | 8 | 39 | 1.491 | 1.591 | 0.100 | 6.930 |
| 11 | 1987 | 4 | 43 | 1.591 | 1.633 | 0.042 | 16.500 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | 1988 | 5 | 48 | 1.633 | 1.681 | 0.048 | 14.437 |
| 13 | 1989 | 4 | 52 | 1.681 | 1.716 | 0.035 | 19.800 |
| 14 | 1990 | 9 | 61 | 1.716 | 1.785 | 0.069 | 10.043 |
| 15 | 1991 | 8 | 69 | 1.785 | 1.838 | 0.053 | 13.075 |
| 16 | 1992 | 6 | 75 | 1.838 | 1.875 | 0.037 | 18.729 |
| 17 | 1993 | 15 | 90 | 1.875 | 1.954 | 0.079 | 8.772 |
| 18 | 1994 | 14 | 104 | 1.954 | 2.017 | 0.063 | 11.000 |
| 19 | 1995 | 9 | 113 | 2.017 | 2.053 | 0.036 | 19.250 |
| 20 | 1996 | 9 | 122 | 2.053 | 2.086 | 0.033 | 21.000 |
| 21 | 1997 | 5 | 127 | 2.086 | 2.103 | 0.017 | 40.764 |
| 22 | 1998 | 15 | 142 | 2.103 | 2.152 | 0.049 | 14.142 |
| 23 | 1999 | 22 | 164 | 2.152 | 2.214 | 0.062 | 11.177 |
| 24 | 2000 | 11 | 175 | 2.214 | 2.243 | 0.029 | 23.896 |
| 25 | 2001 | 21 | 196 | 2.243 | 2.292 | 0.049 | 14.142 |
| 26 | 2002 | 22 | 218 | 2.292 | 2.338 | 0.046 | 15.065 |
| 27 | 2003 | 11 | 229 | 2.338 | 2.359 | 0.021 | 33.000 |
| 28 | 2004 | 28 | 257 | 2.359 | 2.409 | 0.050 | 13.860 |
| 29 | 2005 | 18 | 275 | 2.409 | 2.439 | 0.030 | 23.100 |
| 30 | 2006 | 21 | 296 | 2.439 | 2.479 | 0.040 | 17.325 |
| 31 | 2007 | 22 | 318 | 2.479 | 2.502 | 0.023 | 30.130 |
| 32 | 2008 | 14 | 332 | 2.502 | 2.521 | 0.019 | 36.473 |
| 33 | 2009 | 18 | 350 | 2.521 | 2.544 | 0.023 | 30.130 |
| 34 | 2010 | 21 | 371 | 2.544 | 2.569 | 0.025 | 27.720 |
| 35 | 2011 | 12 | 383 | 2.569 | 2.583 | 0.014 | 49.500 |
| 36 | 2012 | 14 | 397 | 2.583 | 2.598 | 0.015 | 46.200 |
| 37 | 2013 | 9 | 406 | 2.598 | 2.608 | 0.010 | 69.300 |
| 38 | 2014 | 17 | 423 | 2.608 | 2.626 | 0.018 | 38.500 |
| 39 | 2015 | 10 | 433 | 2.626 | 2.636 | 0.010 | 69.300 |
| 40 | 2016 | 21 | 454 | 2.636 | 2.657 | 0.021 | 33.000 |
| 41 | 2017 | 19 | 473 | 2.657 | 2.674 | 0.017 | 40.764 |
| 42 | 2018 | 15 | 488 | 2.674 | 2.688 | 0.014 | 49.500 |
| 43 | 2019 | 18 | 506 | 2.688 | 2.704 | 0.016 | 43.312 |
| 44 | 2020 | 13 | 519 | 2.704 | 2.715 | 0.011 | 63.000 |
| 45 | 2021 | 18 | 537 | 2.715 | 2.729 | 0.014 | 49.500 |
| 46 | 2022 | 14 | 551 | 2.729 | 2.741 | 0.012 | 57.750 |
| 47 | 2023 | 8 | 559 | 2.741 | 2.747 | 0.006 | 115.500 |
| 48 | 2024 | 10 | 569 | 2.747 | 2.755 | 0.008 | 86.625 |
| 49 | n.d. | 4 | 573 | 2.755 | -- | | |

3 shows relationship between CGR and Dt through drawing of line graphs.

## CONCLUSION

After 48 years of active research, Dr. Ian Frazer has retired from full-time laboratory work but remains a prominent and influential leader in global health. He continues to contribute significantly to international health policy, vaccine advocacy, and cancer prevention. Dr. Frazer plays a key role in global efforts to eliminate cervical cancer, actively supporting initiatives led by the World Health Organization (WHO) and other major public health organizations. He holds several prestigious positions, including President of Cancer Council Australia, Chairman of the Australian Cancer Research Foundation's Medical Research Advisory Committee, and serves as an advisor to both the WHO and the Bill and Melinda Gates Foundation on papillomavirus vaccines. In addition, he consults for pharmaceutical companies on immunomodulatory therapies and vaccine development and serves on the boards of several biotech firms and non-profit organizations. Dr. Frazer is best known as the co-inventor of the first vaccine for Human Papillomavirus (HPV), **Gardasil**, developed with his late colleague Dr. Jian Zhou. First approved in 2006, the vaccine targets HPV strains responsible for about 70% of cervical cancers. It has now been adopted in over 130 countries and has led to a significant reduction in HPV infections and cervical pre-cancerous lesions among vaccinated populations. This innovation is widely regarded as one of the most significant medical breakthroughs of the 21st century. The global implementation of the HPV vaccine has strong potential to eradicate cervical cancer as a public health threat. January is recognized as Cervical Cancer Awareness Month in the United States, highlighting the urgency of early detection and vaccination. With the WHO's global strategy aiming to eliminate cervical cancer by 2030 (WHO, 2025), many nations are aligning efforts to meet three key targets: widespread HPV vaccination, effective cervical screening, and timely treatment of pre-cancerous conditions. When diagnosed early and treated promptly, cervical cancer is highly curable.

## ACKNOWLEDGEMENT

This work is dedicated to all parents, encouraging them for their daughters by ensuring they receive timely vaccinations, including the HPV vaccine. By doing so, they play a vital role in helping their children lead a healthier, cancer-free life in the future.

## CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

## ABBREVIATIONS

**TP:** Total Publications/Papers; **CmP:** Cumulative Papers; **ABA:** Author's Biological Age; **PPA:** Paper Productive Age; **SAP:** Single-Authored Paper; **MAP:** Multi-Authored Paper; **DC:** Degree of Collaboration; **APC:** Annual Publication Count; **P/Y:** Papers per Year; **MTT:** More Than Ten; **YFP:** Year of First Publication; **YLP:** Year of Last Publication; **2A:** Two-authored and so on; **Y(O):** Observed/Actual Number of Authors; **Y(E):** Expected/Calculated Number of Authors; **Cum%:** Cumulative percentage; **GS:** Google Scholar; **RG:** ResearchGate; **PM:** PubMed; **SC:** Scopus; **AoP:** Age of Paper; **CGR:** Citation Growth Rate; **VLP:** virus-like Particles; **TS:** Time Span; **% of PG:** Percentage of Publication Growth.

## SUMMARY

This paper presents a detailed bibliometric assessment of Dr. Ian Hector Frazer's scientific contributions to cervical cancer research, particularly focusing on his pioneering work in the development of the Human Papillomavirus (HPV) vaccine. Dr. Frazer, a Scottish-born Australian immunologist, is internationally recognized for co-developing the first successful HPV vaccine, a landmark advancement that significantly reduced the global burden of cervical cancer. The study evaluates a curated set of 573 publications authored by Dr. Frazer between 1977 and 2024. The data, primarily collected from Google Scholar and his institutional profile at the Frazer Institute, were meticulously filtered and analyzed using standard bibliometric methods. The analysis provides quantitative insights into his scholarly output, research collaborations, publishing trends, and citation impact. Key findings reveal that Dr. Frazer has maintained a high level of research productivity over nearly five decades, with 76 single-authored and 496 co-authored works. His most productive phase was from 2002 to 2006, during which he published 100 papers. The journal *Virology* hosted the highest number of his articles (26), and his most cited paper, published in 1997, garnered 1,325 citations on Scopus. His close collaboration with G.J. Leggatt, a frequent co-author on 76 papers, underscores the collaborative nature of his research approach. Dr. Frazer's Productivity Coefficient of 0.63 and a median productivity age of 30 highlight his consistent and sustained scientific engagement. This is the original and first full-scale bibliometric profile of Dr. Frazer's academic legacy. It contributes significantly to the fields of cancer research, vaccine development, and medical science history, offering valuable information to a wide audience including researchers, students, biographers, and science historians. The findings reinforce Dr. Frazer's role as a transformative figure in medical research, whose work continues to impact public health worldwide.

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