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Research Article

Scientometric Portrait of Dr. Jian Zhou, A Chinese Virologist and Co-Inventor of HPV Vaccine

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ABSTRACT

The main aim of this study is to assess cervical cancer research related to Human Papillomavirus (HPV) infections, with a specific focus on the scientific contributions of Dr. Jian Zhou, a distinguished Chinese virologist whose pioneering work led to the development of the HPV vaccine. Using bibliometric techniques, this study quantitatively analyses his research output and evaluates his impact on the field of cervical cancer prevention. Cervical cancer, recognized since 400 BCE, was once considered untreatable. However, advances in medical research identified the Human Papillomavirus (HPV) as its primary cause. A major breakthrough occurred in 2006 with the introduction of the HPV vaccine, which significantly reduced cervical cancer risk. This monumental achievement is attributed to Jian Zhou and his collaborator, Ian Frazer, who developed the vaccines Gardasil and Cervarix. Zhou's contributions have since been acknowledged as pivotal in global efforts to prevent cervical cancer. Data for this study were collected from 42 publications authored or co-authored by Zhou during his ten active research years, sourced primarily from Google Scholar and other databases. The information was organized and analysed using bibliometric methods to create a comprehensive profile of his research productivity. Findings reveal that Zhou published 42 papers on HPV, 26 of which appeared between 1990 and 1999, while 16 were posthumously published. All his works were co-authored, predominantly with Ian Frazer (40 joint papers). The majority of his publications (58.14%) were journal articles, with 12 appearing in *Virology*. His most cited paper (1991) received 774 citations. His productivity coefficient was 1, indicating steady research activity averaging 23 papers annually. This study, the first detailed bibliometric analysis of Jian Zhou's contributions, offers valuable insights into his lasting impact on medical research, cancer immunology, and vaccine development.

Keywords: Bibliometrics, Bio-bibliometrics, Cancer Research, Cervical Cancer, Cervix Uteri, Female Cancer, Human Papillomavirus, Ian H Frazer, Informetrics, Jian Zhou, J. Zhou.

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INTRODUCTION

Cancer is of various types, and its name typically reflects the specific organ it affects. Several scientists worked and are working in developing cancer vaccines for different kinds of cancer. If it is detected at the primary stage, it may cure totally. Otherwise, this is a dangerous and lethal disease. One significant form of cancer is cervical cancer, which originates in the cervix, the lower part of the uterus of women. In November 2005, scientists gathered at Times Square in New York City announced the exciting news of the successful development of the world's first cervical cancer vaccine by Ian Frazer and his team. After 7 years of Zhou's death his closest research associate Frazer finally developed the vaccine and received approval by US Federal Drug Administration (FDA). The cervical cancer vaccine, which is able to protect unexposed women against the infection with four HPV strains responsible for 70% of cervical cancers, was approved for human use by the US FDA and a number of other countries. Zhou is that person who was the frontliner of this groundbreaking discovery of the 21st century. He started studies on HPV when he went on to study at the Zhejiang Medical University for a Master's degree in Medical Sciences. Zhou began to study the human papillomavirus here and developed his interest in the field of human pathology. In 1985, Zhou began his PhD studies in human pathology at the Henan Medical University where he continued his research in human papillomavirus. During that time, he also attended the Institute of Virology, Chinese Academy of Preventive Medicine and studied molecular virology and molecular cloning technology. During his Master's degree and PhD studies, Zhou discovered that the development of esophageal cancer is associated with human papillomavirus infections (Zhao *et al.*, 2017). According to GLOBOCAN 2022, there were approximately 662,301 new

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

This episode begins with Dr. Jian Zhou, a Chinese virologist who played a key role in developing the first HPV vaccine to prevent cervical cancer. Sadly, he passed away at the young age of 42 before completing the research. His close collaborator, Ian Frazer, continued their work after his death. Together with their research team, their efforts led to the successful development of the HPV vaccine, which was introduced in 2006.

Cervical Cancer and Human Papillomavirus (HPV)

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 (Koley, 2025a).

Over more than two thousand years, knowledge of cervical cancer and Human Papillomavirus (HPV) has advanced significantly through major scientific breakthroughs (Wikipedia, 2025; Lowy, 2024; Koley, 2025a). Beginning with Hippocrates' description of cervical cancer as untreatable in 400 BCE, progress accelerated in the 1900s with Hinselmann's colposcope (1925), Papanicolaou's discovery of abnormal cervical cells (1928), and the Pap smear in 1941. Improvements followed with the Aylesbury spatula in 1946 and the first electron-microscope images of HPV in 1949. By 1963, researchers had described HPV's DNA, paving the way for Harald zur Hausen's ground-breaking 1970s hypothesis linking HPV to cervical cancer, confirmed in 1983. This work ultimately enabled the development of the first HPV vaccine in 2005-2006 and zur Hausen earned the 2008 Nobel Prize. Later studies in 2015 and 2018 showed broader vaccine protection and the effectiveness of single-dose vaccination, enhancing global prevention efforts.

HPV, a 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 (WHO, 2025; NIH, 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.

BRIEF BIOGRAPHY OF JIAN ZHOU

Early Life and Education

Jian Zhou was born on February 24, 1957, in Hangzhou, Zhejiang Province, China. At the time of his birth, his father was already 50 years old, and the arrival of a son brought great joy and renewed hope to the family. As a child, Zhou was lively, energetic, and full of curiosity. Zhou spent his formative years in Hangzhou. After graduating from high school, his educational path was interrupted by the Cultural Revolution in China, which resulted in him being sent to work in a rural village. With no schools available, Zhou spent this time working alongside farmers, an experience that deeply shaped his empathy for the struggles of rural life. After about a year of laboring on farms, he returned to Hangzhou and took up temporary work at the "June-One Knitting Factory," where he hauled heavy carts and packages, some weighing over 50 kg for a daily wage of just eighty cents (greater than Rs. 1(INR). Despite the physically demanding work, Zhou remained resilient and never lost his drive. He later secured a position as a welding apprentice at a radio factory. Due to his youth and slender frame, many team leaders were hesitant to take him on. However, one leader recognized Zhou's intelligence, attention to detail, and natural dexterity. With guidance, Zhou quickly mastered welding techniques and began producing high-quality work. He soon became a key member of the team, a position he held until he left the factory to pursue higher education. These early life experiences, working in fields and factories instilled in Zhou a strong work ethic, resilience, and a lasting dedication to scientific advancement. In 1977, Zhou was admitted to Wenzhou Medical College, where he earned his Bachelor of Medicine degree in 1982. He later pursued a Master's degree in Medical Sciences at Zhejiang Medical University, where his research interest in Human Papillomavirus (HPV) and human pathology began to take shape (Zhao *et al*., 2017). In 1985, Zhou commenced his PhD studies in human pathology at Henan Medical University (now the medical school of Zhengzhou University), continuing his focus on HPV. After obtaining his PhD in 1988, he completed a postdoctoral fellowship at Beijing Medical University before moving to the University of Cambridge in the same year to further research in virology and cancer (Wikipedia, 2025; Zhao *et al*., 2017). Zhou is best known for co-developing Gardasil and Cervarix, the groundbreaking vaccines that stimulate the immune system to fight HPV, the primary cause of cervical cancer in women. This achievement, in collaboration with fellow researcher Ian Frazer, has had a profound impact on global public health. He married *Xiao-Yi Sun, classmate at* Wenzhou Medical College (Wikipedia, 2025).

Professional and Research Activities

During his PhD studies in human pathology at Henan Medical University, Zhou also studied at the Institute of Virology, Chinese Academy of Preventive Medicine, where he learned about molecular virology and cloning technology. While working on his Master's and PhD degrees, he discovered a link between Human Papillomavirus (HPV) infections and the development of esophageal cancer. This important finding earned him a national award in China. Later, during his postdoctoral fellowship at Beijing Medical University, he used the vaccinia virus to express a specific protein in the lab, which became a key step toward his future vaccine development. That same year, he was invited to join the Tumor Virus Laboratory at the University of Cambridge, where he continued his HPV research under Lionel Crawford. Thanks to his dedication and innovation, Zhou gained a strong understanding of HPV research and its future direction. He soon began publishing important papers in respected international journals such as the *Journal of General Virology, Virology*, and the *Journal of Virology* (Zhao *et al*., 2017).

Jian Zhou and Ian Frazer

Zhou met Professor Ian Frazer, an immunologist from the University of Queensland, in 1989 while they were both at the University of Cambridge. Frazer was impressed by Zhou's creative research ideas, and the two quickly formed a strong professional bond based on mutual respect. Frazer invited Zhou to join him in Australia to continue their shared research on Human Papillomavirus (HPV). In 1990, Zhou moved to the University of Queensland, where he began what would become the most important part of his scientific career (Zhao *et al*., 2017; Wikipedia, 2025). Together, they started using molecular biology techniques to create Virus-Like Particles (VLPs) in the lab that could mimic the outer shell of HPV. In March 1991, following Zhou's instructions, his wife and fellow researcher, Xiao-Yi Sun, successfully assembled two proteins into a VLP that closely resembled the HPV virus. This breakthrough led to the development of the HPV vaccine. The vaccine offers strong protection for women who have not yet been exposed to HPV, targeting four strains of the virus responsible for about 70% of cervical cancer cases, which claim around 250,000 lives each year. Frazer and Zhou filed a provisional patent in June 1991 and continued vaccine development at the University of Queensland (Wikipedia, 2025). In July of that year, Zhou and Frazer reported their results at the International Conference of Human Papillomavirus in Seattle in the United States (Zhao *et al*., 2017). To support clinical trials, they licensed parts of the patent to the Australian medical company CSL and later to Merck company, USA. Both companies carried out extensive animal and human clinical trials, which ultimately confirmed that the human papillomavirus-like particles were effective in preventing cervical cancer (Zhao *et al*., 2017; Wikipedia, 2025). CSL gained the rights to sell the vaccine (Gardasil) in Australia and New Zealand, while Merck secured the rights for the rest of the world. Around the same time, Glaxo Smith Kline developed a similar vaccine, Cervarix, using the same VLP method under a separate U.S. patent, and licensed Frazer's intellectual property in 2005 (Wikipedia, 2025).

Teaching, Research, and Grants

Zhou earned his MD from the University of Queensland in 1994 and went on to become an Associate Professor at Loyola University in Chicago, where he led a research group and mentored PhD students and postdocs. He returned to the University of Queensland in 1996 as the principal Lions Research Fellow and Head of the Papillomavirus Structural Protein Lab. By 1998, he had secured multiple prestigious research grants from both Australian and American institutions, including the NHMRC, NIH, and Cancer Council Queensland. That year, he became the highest-funded researcher in the university's history, also receiving royalties from his patents (Zhao *et al*., 2017).

Dr. Zhou's Other Discoveries

Zhou was a highly skilled scientist whose work in papillomavirus and cancer biology was outstanding. Over his career, he made several groundbreaking discoveries and secured twelve invention patents within eight years. Some of his most important findings include (Zhou *et al*., 1999, 1991,1991a; Zhao *et al*., 2017):

1) Identifying that the L2 protein of the papillomavirus is essential for binding DNA and forming the virus shell, which highlighted its key role in the virus life cycle.

2) Discovering that the end part of the L1 protein isn't needed to form virus shells, which helped create a new type of vaccine using modified virus proteins to boost both prevention and treatment.

3) Showing that the virus's L1 and L2 genes don't work well in most mammalian cells because of differences in tRNA, but can be expressed in yeast.

4) Finding that changing the genetic code to match the host's tRNA could improve how well these proteins are made in human cells. This method, called codon optimization, helped increase vaccine effectiveness and opened the door for new gene therapy approaches.

Zhou and Alumni Institution

Jian Zhou maintained a profound connection with his alma mater, *Wenzhou Medical University*, where he completed his medical education. Deeply committed to its academic and research advancement, he consistently supported the institution's growth in teaching and scientific inquiry. He frequently visited the university to deliver lectures and mentor young researchers, often dedicating his personal time and resources. Demonstrating exceptional generosity, Zhou personally financed opportunities

for scholars from Wenzhou to pursue further studies abroad. Even while engaged in international research, he envisioned continuing scientific work at his home institution, undeterred by the financial burden. After joining the *University of Queensland*, he played a pivotal role in establishing a collaborative program between the two universities. This partnership not only strengthened joint research efforts but also facilitated student exchanges, significantly contributing to the global exposure and development of Wenzhou Medical University. Zhou's unwavering dedication exemplifies his lifelong commitment to education, collaboration, and the scientific progress of his alma mater (Zhao *et al*., 2017).

Recognition and Tributes toZhou

Jian Zhou is best known for co-developing *Gardasil* and *Cervarix*, the vaccines that help the immune system fight HPV-the main cause of cervical cancer in women. For this major achievement, he received a national award in China. To carry on his legacy, his family created the Dr. Jian Zhou Foundation, which gives scholarships to medical students from Wenzhou Medical University (his Alumni Institution) to study for PhDs abroad and become medical researchers. Zhou played an important role in helping Wenzhou Medical University grow into a respected university in China and around the world. His great contributions to science and humanity have been honored in many ways. The *University of Queensland's Diamantina Institute* holds an annual *Jian Zhou Memorial Oration*, where leading scientists give talks in his memory, and one of their conference rooms is named after him. Since 2000, the international HPV Conference has also paid tribute to him several times. In 2006, the *AOGIN* organization created the *Jian Zhou Award* for the best oral presentation. That same year, the *Queensland Government* started the *Dr. Jian Zhou Smart State Fellowships Program*. A memorial event was also held by the Queensland Government along with Chinese and Australian community groups, and a book was published titled *"Dr. Jian Zhou's Brilliant Mind: The Inventor of Cervical Cancer Vaccine."* Finally, in 2015, the HPV vaccine he co-invented with *Ian Frazer* won the *European Inventor Award,* a major recognition of their life-saving work (Zhao *et al*., 2017). In addition, the *Jian Zhou Medal*, awarded annually by the *Australian Academy of Health and Medical Sciences*, recognizes an emerging leader in Australian health and medical research-an individual making a significant impact in *translational medical science* while primarily based in Australia (AAHMS, 2025).

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. 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 bio-bibliometrics, and presented a scientometric portrait of the renowned astronomer Jan Hendrik Oort, respectively. Mondal *et al*. (2018) produced a bio-bibliometric account of Prof. P. C. Mahalanobis, a distinguished Indian statistician. 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 works of Saeed Ullah Jan in the field of Library and Information Science. In 2023, 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) analysed the economic research of 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; 2025a) presented two bio-bibliographic studies on Suprabhat Mukherjee, a colon cancer researcher, and evaluation of Ian Frazer, a leading medical scientist and future researcher of J. Zhou, best known for his role in developing the HPV vaccine. Therefore, the present study aims to fill this gap by providing a comprehensive bibliometric assessment of Dr Zhou's research contributions. Hence, this study is important and original. Zhou represents a valuable informetric case because his career spans both an active lifetime and a long posthumous publication phase, allowing a rare examination of how scholarly influence continues after a researcher's death. His consistent collaborative patterns, multi-authored outputs, and stable productivity over two decades provide an unusually clean dataset for analysing longitudinal authorship behaviour and collaborative dynamics.

This study extends previous authored-centered informetric profiles by explicitly modelling *posthumous productivity* and documenting how stable collaboration networks can sustain publication output long after an author's active career ends. It also highlights an exceptional case where multi-authorship remains constant (DC=1.00), offering fresh insight into the durability of collaborative structures and the role of co-author networks in perpetuating academic impact.

OBJECTIVES OF THE STUDY

The main objectives of this study are:

- To prepare for a year and age- wise research outputs of Jian Zhou.
- To observe publications between 1990 and 1999 (active productive life) 2000 and 2011 (Posthumous).
- To determine his position as main author and co-author.
- To examine and analyze authorship patterns.
- To measure the DC, IC, CC, MCC from his publication patterns.
- To learn about leading collaborators.
- To find out the peak period of productivity.
- To identify channel wise scattering of publications.
- To analyze citations received from his papers.

METHODS

Data Materials

This study analyses 42 research publications authored or co-authored by *Jian Zhou*, covering the period from 1990 to 2011. These publications appeared in multiple formats, including journal articles, conference papers, book chapters, and patents, reflecting the breadth of Zhou's scientific output and collaborative engagement within the medical research community.

Data Collection

The primary source of data for this study was Google Scholar, selected for its extensive coverage of multidisciplinary research outputs from the profile of his co-author Ian H Frazer. This approach was necessary because the author's profile was not directly available in major indexing databases. To enhance the accuracy and completeness of the publication list, additional authoritative sources were consulted, including Ian H Frazer's profile in Google scholar, PubMed, ResearchGate, institutional repositories, and secondary references from published articles e.g. Zhao *et al.* (2017), as well as Wikipedia (2025). Searches were performed using multiple variations of the author's name, such as "J. Zhou," "Jian Zhou," "Zhou J.," and "Ian H. Frazer," across platforms including Google Search, Google Scholar, PubMed, and ResearchGate. Each retrieved record was systematically verified based on criteria such as author identity, institutional affiliation, publication year, and recurring co-authors (e.g. Ian H. Frazer), enabling accurate differentiation between individuals with similar names. This multi-database strategy minimized the risk of missing relevant records and ensured a comprehensive overview of Zhou's scholarly contributions. All entries were cross-checked for consistency in authorship, publication year, title, journal or publisher, and citation metrics. In cases where discrepancies in citation counts were observed across databases (e.g., Google Scholar versus Scopus), values from Google Scholar were adopted due to its broader indexing coverage, particularly in biomedical research. It should be noted that only a limited number of publications (e.g., three records) were retrieved from PubMed, and no records were found on ResearchGate.

Posthumous Publications: Why

Zhou's posthumous publications are included in this study because, following his death, Ian H. Frazer continued his research on Human Papillomavirus and contributed significantly to the development of the HPV vaccine. Many of Frazer's subsequent

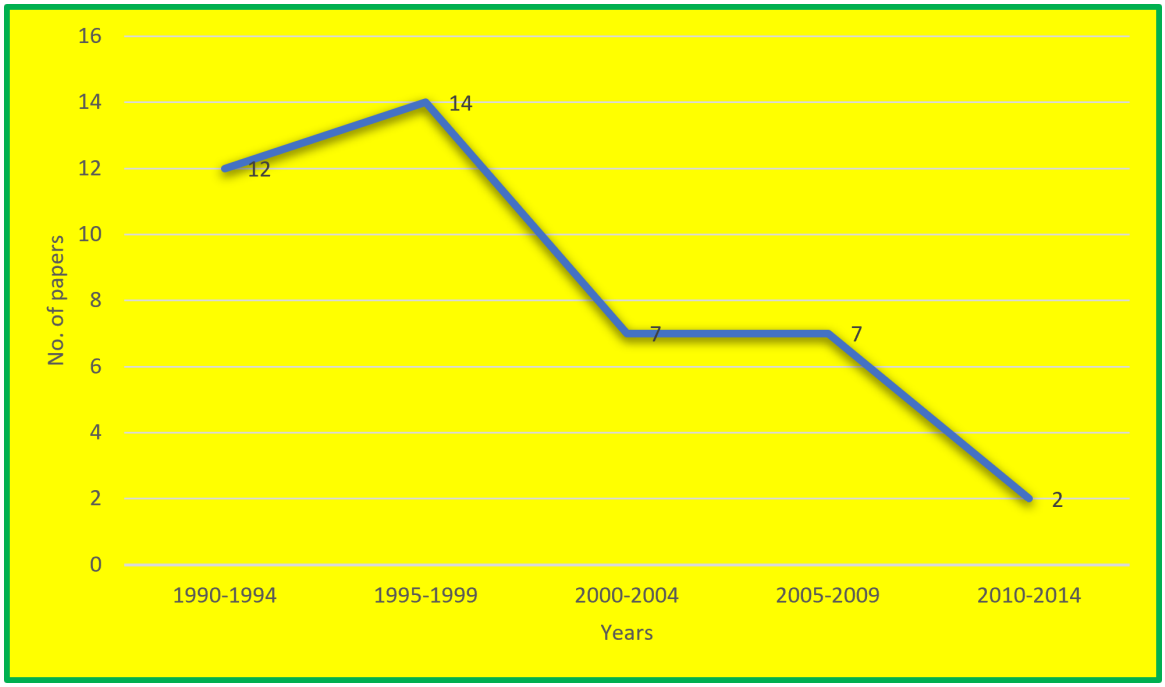

Figure 1: Diminishing production curve of paper with the growing of age in active life and after death.

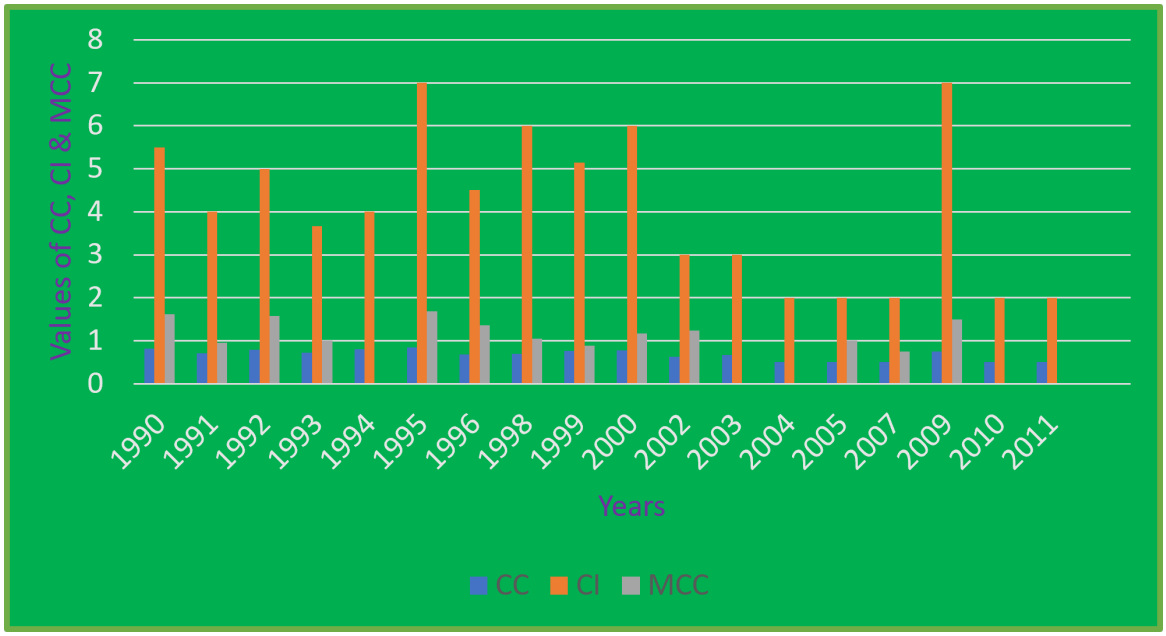

Figure 2: Showing rate of CI, CC and MCC.

publications related to Zhou's work could not be completed without acknowledging Zhou's foundational contributions. Frazer's work on Human Papillomavirus and the development of the HPV vaccine was deeply rooted in Zhou's earlier research. Consequently, Zhou's contributions remain integral to these publications, and his name has been consistently acknowledged to recognize his enduring influence and remarkable achievements. Thus, all posthumous publications have accorded equal credit to Zhou.

Data Organization

After collection, all data were *cleaned, standardized, and tabulated* using *Microsoft Excel* for quantitative analysis and *Microsoft Word* for descriptive summaries. Duplicate records were removed and missing bibliographic details were manually verified. The structured organization of bibliographic information enabled clear visualization of publication trends over time. This step was essential for identifying productivity patterns, collaborative intensity, and preferred publication outlets.

Bibliometric Analysis

Standard *bibliometric techniques* were applied to assess *publication productivity, authorship patterns, co-authorship networks, journal distribution, and citation impact,* formulas for DC, CI, CC and MCC, *Metrics such as the Productivity Coefficient, median year of productivity, most-cited publications and* were calculated to evaluate research performance.

Bibliometric analysis provided a quantitative framework for understanding Zhou's scientific influence. It revealed the consistency of his research activity, his close collaboration with Ian Frazer, and the sustained citation impact of his early HPV vaccine studies.

Terms such as bio-bibliometric, bibliometric, and scientometric are often used interchangeably with bibliometric analysis, although they represent related but distinct concepts. Bibliometric analysis refers to the application of statistical and mathematical methods to books, research publications, and other information sources in order to measure productivity and assess their impact on the information landscape. Bio-bibliometric analysis focuses specifically on the biographical and bibliographical data of an individual whether living or deceased across various disciplines worldwide. Scientometrics, a closely related field, deals primarily with the quantitative analysis of scientific literature and research output, often emphasizing the evaluation of contributions within the scientific domain.

Additional biographical and contextual data were gathered from credible online and offline resources, including biographical profiles, interviews, institutional websites, and obituaries. These qualitative insights helped contextualize bibliometric findings within Zhou's academic journey and historical significance.

Integrating biographical context enriched quantitative analysis, transforming numerical trends into a narrative of scientific development. This approach strengthened the overall validity and interpretative depth of the study.

Through a rigorous combination of *quantitative bibliometrics and qualitative contextual analysis*, this study constructed a holistic profile of Jian Zhou's research career. The methodology ensured both statistical accuracy and interpretive depth, allowing a balanced understanding of his lasting impact on HPV vaccine development and medical science.

RESULTS

Data Analysis And Discussion

Year and Age wise Publications

Table 1 presents year and age wise 42 publications of Jian Zhou (born in 1957), divided into two phases: Active Productive Life (A) from 1990 to 1999, and Posthumous Life (P) from 2000 to 2011, along with degree of collaboration.

Degree of Collaboration (DC)

The degree of collaboration is measured using the following formula (Deshmukh and Kanchi, 2024).

$$DC=\frac{Nm}{Nm+Ns}$$

Where,

N_m=Number of multiple -authored papers=MAP

N_s = Number of single authored papers=SAP

So, DC value for the year 1999=$\frac{Nm}{Nm+Ns}=\frac{2}{2+0}=\frac{2}{2}=1$ and so on.

Fifty Percentile Age

Half of Jian Zhou's total publications (21 papers) were produced by the end of 1999, indicating a highly productive scientific career that spanned just 10 active years-highlighting the intensity and impact of his contributions within a remarkably short period.

Productivity Coefficient (PC)

The Productivity Concentration (PC) ratio is 1.0 (10/10), indicating that 50% of Jian Zhou's publications were produced evenly across his entire active productive period-a sign of consistent scientific output throughout his career.

Table 1: Year and age wise publications.

Year	TP	CP	AA (b.1957)	PPA	SAP	MAP	Authorship Status								CoA	DC= MAP/ TP
							1st	2nd	3rd	4th	5th	6th	7th	9th		
	Active Productive Life (A)															
1990	2	2	33	1	0	2	2								9	1.00
1991	4	6	34	2	0	4	4								12	1.00
1992	2	8	35	3	0	2	2								8	1.00
1993	3	11	36	4	0	3	2	1							8	1.00
1994	1	12	37	5	0	1	1								3	1.00
1995	2	14	38	6	0	2					1			1	12	1.00
1996	2	16	39	7	0	2	1					1			7	1.00
1998	3	19	41	9	0	3				2				1	15	1.00
1999	7	26	42	10	0	7	1	1	3		2				29	1.00
Total (A)	**26**				0	**26**	**13**	**2**	**3**	**2**	**3**	**1**		**2**	**103**	1.00
	Posthumous Life (P)															
2000	3	29			0	3		3							13	1.00
2002	2	31			0	2		1	1						4	1.00
2003	1	32			0	1		1							2	1.00
2004	1	33			0	1		1							1	1.00
2005	2	35			0	2		2							2	1.00
2007	3	38			0	3		3							3	1.00
2009	2	40			0	2		1					1		12	1.00
2010	1	41			0	1		1							1	1.00
2011	1	42			0	1		1							1	1.00
Total (P)	**16**				0	16		14	1				1		**39**	1.00
GT=A + P	42				0	42	13	16	4	2	3	1	1	2	142	1.00

Average Annual Publications (AP)

Jian Zhou's Average Productivity (AP) is 2.6 (26 papers over 10 years), reflecting a strong and steady output of approximately 2 to 3 publications per year during his active research career.

Peak Productivity Age

He peaked productivity when he was 42 years old (1999) and published 7 papers in that year, the year of his death.

Quinquennium wise Publications

Table 2 shows the quinquennial (5-year) distribution of publications during both the Active Productive Life (A) and Posthumous Life (P) of the author born in 1957. Apart from that it also accounted for peak productivity period.

Figure 1 illustrates the number of papers published over five time periods, highlighting a peak in productivity during 1995-1999, followed by a decline that may reflect the impact of the individual's death, presumed to have occurred around 1999.

Collaborative Publications

The data in Table 3 clearly shows that all 42 publications were collaborative, with no single-author (non-collaborative) papers, highlighting the author's strong preference for teamwork and scholarly collaboration.

CC, CI AND MCC

Table 4 shows the authorship pattern and collaboration metrics (CC, CI, MCC) of research papers from 1990 to 2011.

Collaboration Index (CI)

The Collaborative Index (CI) is the average number of authors per article in a given set of publications. It serves as a basic indicator of collaborative activity in research (Yadav *et al.*, 2019). Symbolically,

$$CI = \frac{\Sigma Aj = 1jfj}{N}$$

Where,

j=number of authors in an article (i.e. 1, 2, 3…),

fj=number of j authored papers,

N=total number of papers published in a year, and

A=the total number of authors per article.

$$\text{Alternatively, CI for a particular year} = \frac{(1AxNP)+(2AxNP)+(3AXNP)+soon}{N}$$

Here, 1A=Single-authored paper,

2A=Double-authored paper,

3P=Triple-authored paper, and

NP=Number of papers according to authorship,

N=Total Number of papers of a year.

For example,

$$\text{CI for } 1990 = \frac{(1A \times NP)+(2A \times NP)+(3A \times NP)+\cdots+(12A \times NP)}{N}$$

$$= \frac{(0 \times 0)+(0 \times 0)+(0 \times 0)+(4 \times 1)+(5 \times 0)+(6 \times 0)+(7 \times 1)+(9 \times 0)+(10 \times 0)+(11 \times 0)+(12 \times 0)}{2}$$

$$= \frac{0+0+0+4+0+0+7+0+0+0+0}{2} = \frac{11}{2} = 5.5$$

and so on.

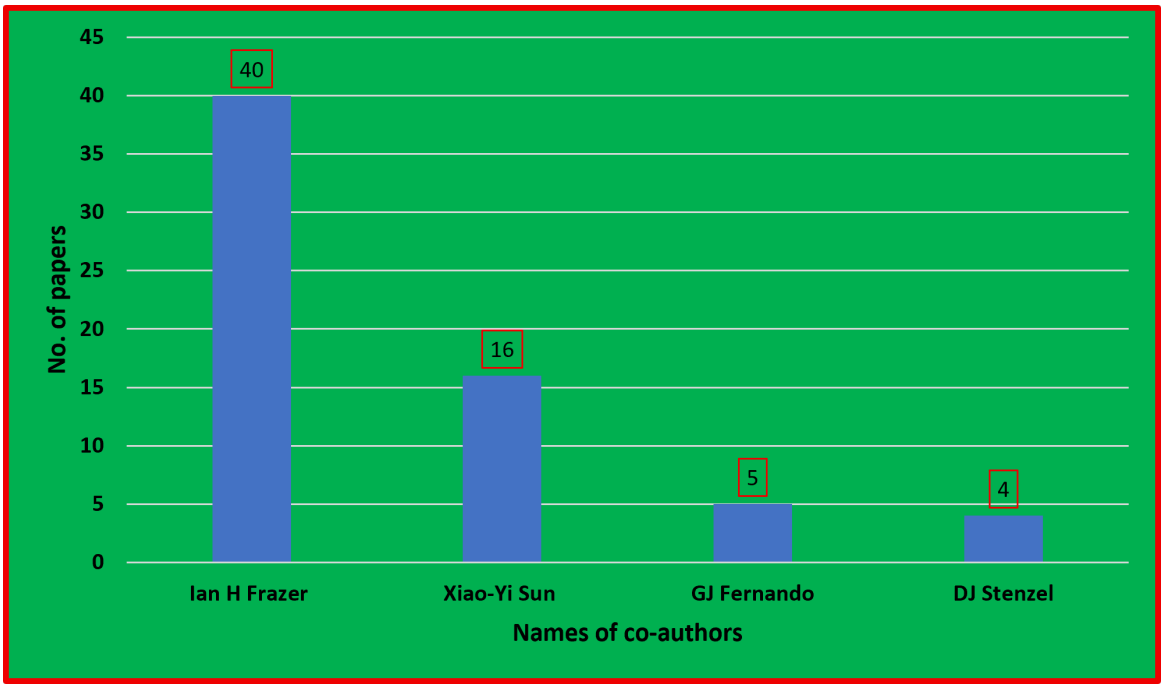

Figure 3: Articles published withZhou by co-authors (First four single leading co-authors).

Collaboration Coefficient (CC)

It quantifies the proportion of multi-authored papers in relation to the total number of papers published, helping to assess the extent of collaborative research within a given dataset or discipline (Yadav *et al*., 2019). Symbolically,

$$CC=1-\frac{\sum Aj=1(\frac{1}{j})\,fj}{N}$$

Where,

j=the number authors in an article i.e. 1, 2, 3 ……

fj=the number of j authored articles.

N=the total number of articles published in a year.

For example,

$$\text{CC for } 1990=1-\frac{(\frac{1}{1}x\,0)+(\frac{1}{2}x\,0)+(\frac{1}{3}x\,0)+(\frac{1}{4}x\,1)+(\frac{1}{5}x\,0)+(\frac{1}{6}x\,0)+(\frac{1}{7}x\,1)+(\frac{1}{9}x\,0)+(\frac{1}{10}x\,0)+(\frac{1}{11}x\,0)+(\frac{1}{12}x\,0)}{2}$$

$$=1-\frac{0+0+0+0.25+0+0+0.14+0+0+0+0}{2}$$

$$=1-\frac{0.39}{2}$$

$$=1-0.19=0.81$$

and so on.

This metric is often used in bibliometric studies to understand collaboration trends across authors, institutions, or countries.

Modified Collaboration Coefficient (MCC)

The MCC is a bibliometric indicator used to measure the degree of collaboration in scientific research. It's a refinement of the original Collaboration Coefficient (CC), which quantifies the extent of co-authorship in scholarly publications (Yadav *et al*., 2019). Symbolically,

$$MCC=(\frac{N}{N-1})\,\{1-\frac{\sum Aj=1(\frac{1}{j})\,fj}{N}\}\text{or}$$

Shortly,

$$MCC=(\frac{N}{N-1})\times CC$$

of each year.

For example,

$$\text{MCC for } 1990=N/(N-1)\times 0.81$$

$$=2/(2-1)\times 0.81$$

$$=2/1\times 0.0.81$$

$$=2\times 0.81$$

$$=1.62$$

and so on.

Figure 2 shows that *CI values* (orange bars) fluctuate widely, peaking notably in 1995 and 2009, while *CC* (blue) and MCC (gray) remain relatively stable throughout the years. Overall, *CI dominates the trend*, indicating higher variability compared to the more consistent CC and MCC values.

Status in Byline of Authorship

Table 5 analyses the position of authors in the byline across 42 multi-authored publications, revealing patterns in authorship contribution.

Leading Co-authors

Table 6 provides an overview of the co-authors who collaborated with Zhou in his research, showing Publication Count (TP), years of first and last collaboration (YFP, YLP), time span, and publications per year (P/Y).

Figure 3 shows a highly uneven collaboration pattern, with Ian H. Frazer dominating as Zhou's primary collaborator (40 papers), followed by a secondary but significant partnership with Xiao-Yi Sun (16 papers). In contrast, G.J. Fernando (5) and D.J. Stenzel (4) reflect occasional, project-specific collaborations. Overall, the Figure reveals a clear core-periphery structure cantered on one major collaborator.

Publication Source Patterns and Impacts

Table 7 shows publication source data that reveals a diversified output across journals, patents, conferences, and book chapters, highlighting both academic and applied research contributions. Table 7 and Figure 4 also show country-wise publications worldwide.

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 42 /2=21 which are published in the first 6 channels (journals) out of a total 27 communication channels. So,

$$PC=(6/27)\times 100=22.22$$

Table 2: Quinquennium wise publications.

Quinquennium (5 years)	AA (b. 1957)	PPA	APC	%-age	P/Y
Active Productive Life (A)					
1990-1994	33-37	1-5	12	28.57	2.4
1995-1999	38-42	6-10	14	33.34	2.8
Posthumous Life (P)					
2000-2004			7	16.66	1.4
2005-2009			7	16.66	1.4
2010-2014			2	4.77	0.4
Total			42	100.00	

Table 3: Authorship pattern.

Authorship Pattern	Single	Two	Three	Four	Five	Six	Seven	Nine	Ten	Eleven	Twelve	Total
Non-collaborative papers	0											0
Collaborative papers		14	3	12	4	2	2	1	1	2	1	42
Time Span		21	7	9	5	2	7	1	1	1	1	
FYP to LYP		1991-2011	1993-1999	1991-1999	1995-1999	1991-1992	1990-1996	1995	1998	1999-2000	2009	

Table 4: CC, CI and MCC according to authorship pattern.

Year	TP	CP	Authorship Pattern										TA	CC	CI	MCC	
			Multiple Authorship														
			2A	3A	4A	5A	6A	7A	9A	10A	11A	12A					
1990	2	2			1			1					11	0.81	5.5	1.62	
1991	4	6	1		2		1						16	0.71	4.00	0.95	
1992	2	8			1		1						10	0.79	5.00	1.58	
1993	3	11		1	2								11	0.72	3.67	1.00	
1994	1	12			1								4	0.80	4.00	0.00	
1995	2	14				1			1				14	0.84	7.00	1.68	
1996	2	16	1					1					9	0.68	4.50	1.36	
1998	3	19			2					1			18	0.70	6.00	1.05	
1999	7	26	1		2	3					1		36	0.76	5.14	0.89	
2000	3	29		1	1						1		18	0.78	6.00	1.17	
2002	2	31	1		1								6	0.62	3.00	1.24	
2003	1	32		1									3	0.67	3.00	0.00	
2004	1	33	1										2	0.50	2.00	0.00	
2005	2	35	2										4	0.50	2.00	1.00	
2007	3	38	3										6	0.50	2.00	0.75	
2009	2	40	1									1	14	0.75	7.00	1.50	
2010	1	41	1										2	0.50	2.00	0.00	
2011	1	42	1										2	0.50	2.00	0.00	
Total	42		13	3	13	4	2	2	1	1	2	1	186	0.63	4.56	4.65	

Publication Density (PD)

PD=Total number of Papers / Total number of channels used=42/27=1.56.

Citation Received and Citation Growth Rate

The data in Table 8 presents a detailed snapshot of the top 14 scholarly publications in the field of papillomavirus research that have received at least 50 citations, focusing on patterns in citation performance, Author Productivity (AoP), Citation Growth Rate (CGR), and publication trends.

Figure 5 shows that the CGR values remain constant at zero for most papers but rise sharply after the 12th paper, reaching their highest point around the 14th paper. This indicates a sudden increase in growth or contribution rate at the later stage.

DISCUSSION

During the active years, the author published 26 Total Papers (TP), all of which were Multi-Authored Publications (MAP) in association with 103 co-authors, meaning the author had a central role in writing them, while 16 Posthumous papers were also collaborative nature with 39 collaborators. His first paper appeared in 1990 when he was 33 years old. This shows a high level of direct involvement and productivity. He reached his peak between 1990 and 1999, remarkably publishing seven papers in 1999, the year he died. The consistent authorship status (mostly as 1st or 2nd author) even after passing reflects the continued relevance and contribution of their research. Interestingly, there was a small pause in publication in some years (1997, 2001, 2006, 2008), which could suggest either gaps in output or administrative or collaborative delays. In total, across both periods, the author contributed to 42 papers, with a clear and consistent pattern of leading roles in authorship. This level of sustained contribution, even after death, highlights the depth, preparation, and collaborative nature of the author's work, showing a strong legacy in their academic field.

The DC ratio is 1.00 every year, because there is no single authored paper, indicating that every paper during this time was significantly authored by them. In the posthumous period, 16 more papers were published, still maintaining a DC of 1.00, suggesting these were likely based on the author's previous work, drafts, or collaborations finalized by co-authors after their death.

The highest publication activity occurred during 19951999, where 14 papers (33.34%) were published with an average of 2.8 papers per year. This suggests a peak in the author's productivity, likely reflecting their career maturity and increased research output. The preceding quinquennium, 19901994, also saw significant output with 12 papers (28.57%), showing steady early growth. However, there's a notable decline in the posthumous period, with only 7 publications (16.66%) in 20002004 and a further dip to 7 (16.66%) in 20052009, averaging just 1.8 papers per year. Overall, the data reflects a strong and sustained productivity during the author's life, followed by a respectful continuation of their work after death, though naturally tapering off with time. The consistency and quality implied by the continuation also highlight the lasting value and influence of the author's contributions.

The author's most productive period was 19951999, during which he published 14 papers, marking the peak of his research activity. The preceding quinquennium, 19901994, with 12 publications, shows a strong upward trajectory leading to this peak. In the three posthumous quinquennia, a total of 16 papers appeared, with both the first and second posthumous phases contributing 7 papers each (16.66%), indicating a continued scholarly output derived from his research legacy.

The most common authorship pattern was two author papers (14 publications) in a time span of 21 years, followed by four author (12 papers) in a time span of 9 years, five-author (4 papers) collaborations in a time span of 9 years and three author (3 papers) in a span of 7 years, etc. This suggests that the author frequently worked in small teams, likely allowing for focused, cooperative research. Larger collaborations involving five or more authors were less frequent but still notable, with occasional instances of up to twelve co-authors (one paper). The presence of high-author-count papers, although rare, may reflect interdisciplinary or multi-institutional collaborations in more complex projects. The time span column shows the longevity and adaptability of the author's collaborative efforts, ranging from

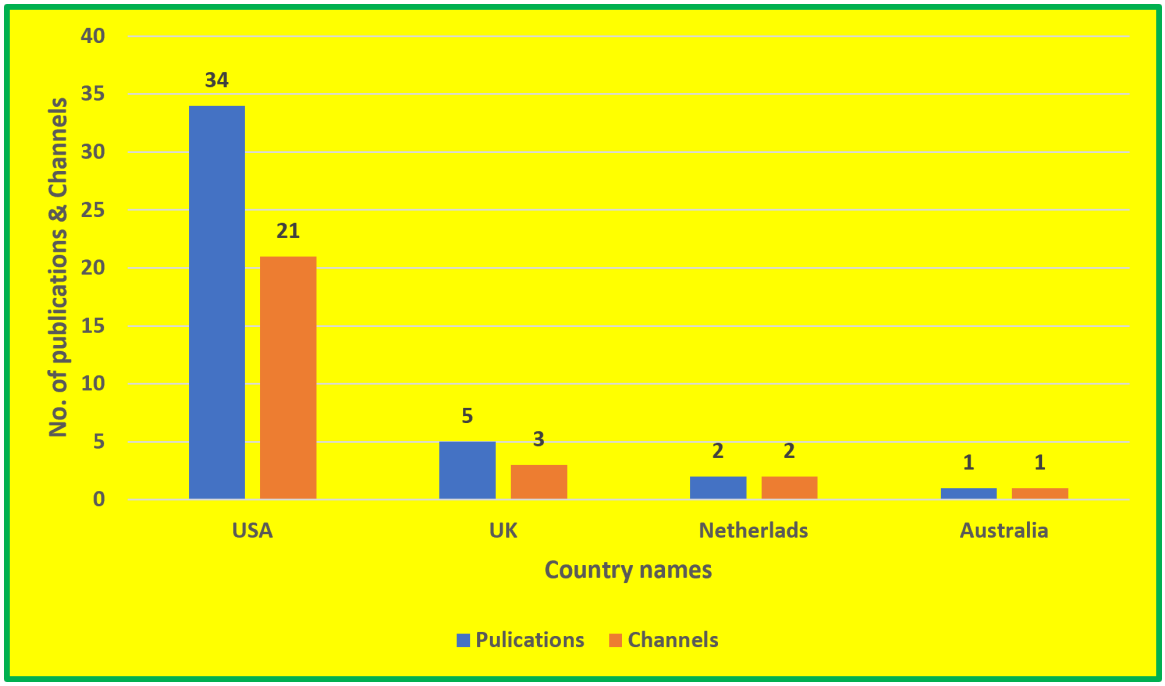

Figure 4: Country wise publications and channels.

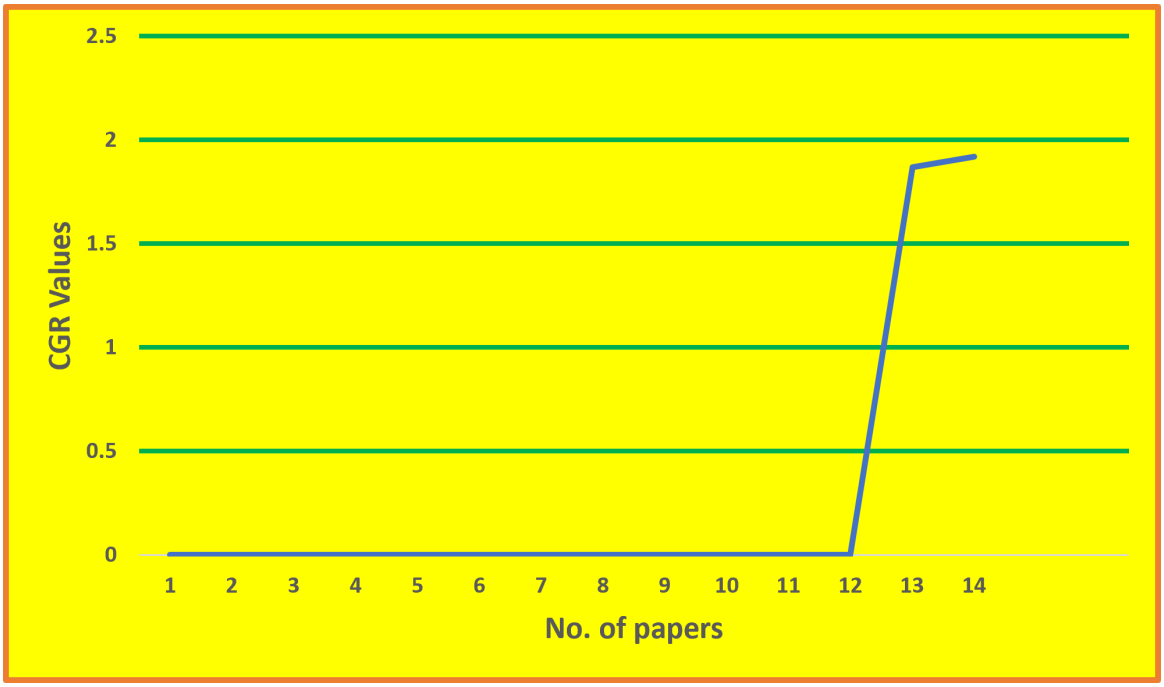

Figure 5: Showing CGR Curve of Citation received.

early two-author papers in 1991 to multi-author papers extending into 2011. Interestingly, the diversity in authorship size over time from two to twelve co-authors demonstrates the author's ability to work across various research team sizes and structures.

It highlights some key notes, those are:

- As there are no single-author papers, the research clearly depends on teamwork, with ideas and work being shared closely among collaborators.
- Most papers (62%) have two or three authors, which suggests the researcher worked mainly in small, trusted teams where people collaborated efficiently.
- This pattern matches fields where most of the thinking and work happens within small research groups rather than large, loosely connected teams.
- Papers with four to twelve authors show that the researcher sometimes took part in bigger, project-based collaborations involving several institutions, though this happened less often.
- Over time, the pattern of co-authorship changed: early in his career, he mostly worked in small teams, but later and even after his death, his work appeared in papers with larger groups of collaborators.
- These long-standing collaborations help explain why publications continued to appear after his death, as his colleagues were still finishing and publishing joint projects.
- Overall, these authorship patterns help us understand how research teams stay connected, how collaboration networks stay strong, and how a scholar's influence can continue even after they are gone.

Over the years, multiple authorship has become common, with all papers involving 2 to 5 authors. In total, there were 42 papers (TP) with 186 Total Authors (TA), averaging about 4.56 authors per paper (CI). The Collaboration Coefficient (CC) was 0.63, indicating a moderate to high level of collaboration among authors. The Modified Collaboration Coefficient (MCC) was 4.65, showing that collaboration increased over time. Some papers even had as many as 12 authors, highlighting growing teamwork in research. Overall, the data suggests that research in this field has become more collaborative, especially after the mid1990s.

The majority of authors occupied the first (13) and second (17) positions, indicating a concentration of key contributions at the beginning of the author list often associated with the main researchers or project leads. Very few authors appeared in later positions such as 6^{th}, 7^{th}, 9^{th}, or beyond, suggesting limited extended collaboration or that recognition diminishes with position. Four-authored papers showed the widest spread of positions, reflecting more balanced collaboration among team members. Interestingly, even in publications with ten or more authors, only one author each was highlighted, indicating that senior or contributing roles may not always be equally represented. Overall, the data suggests a strong emphasis on the leading author roles in most papers, with decreasing visibility or significance as one move down the byline. This aligns with

common academic norms where the first few positions carry the most weight in terms of credit and responsibility.

Notably, Ian H. Frazer stands out as Zhou's closest and most consistent collaborator, with 40 joint publications over 21 years, averaging 1.95 papers per year indicating a long-term, productive research partnership. Xiao-Yi Sun also shows strong collaboration (16 papers), though over a shorter span. Apart, GJ Fernando (5 papers) and DJ Stenzel (4 papers) occupied third and fourth position in a time span of 8 and 4 years respectively. Most other collaborators had significantly fewer joint papers, with 63 out of 67 co-authors contributing to only 13 publications, and many partnerships lasting just a single year. This suggests Zhou maintained a core team of frequent collaborators while also engaging in numerous short term or project-specific collaborations. The high number of single paper co-authors (over 50) indicates a broad but shallow collaboration network beyond his key associates, reflecting Zhou's active participation in interdisciplinary and collaborative research, but with limited long-term partnerships outside his main circle.

Journal articles constitute the majority with 57.14% (24 out of 42) of total publications, indicating a strong emphasis on scholarly communication. The journal *Virology* leads with 12 articles (28.58%), emphasizing its importance as a preferred platform, followed by *Journal of General Virology* and *Journal of Virology* with 3 articles each (7.14%). Notably, the USA dominates the publication landscape, contributing to most journals and all 15 patents (35.72%), reflecting a strong U.S. base in both academic and intellectual property outputs. The presence of patents (35.72%) is particularly significant, suggesting a high degree of innovation and translational research impact. Conference papers (2, 4.76%) and book chapters (1, 2.38%) are minimal, pointing to lesser emphasis on informal or secondary dissemination channels. The First Year of Publication (FYP) dates back to 1990, with the Last Year of Publication (LYP) extending to 2011, indicating over two decades of sustained research activity. It is clear that after his death in 1999, the results of his research activities have had an impact for another 10 years. Overall, the data reflects a research portfolio that is academically robust, innovation driven, and internationally collaborative, with the USA playing a central role.

Out of his 42 publications, the majority (34 papers, 21 channels) originated from the United States, followed by the United Kingdom with 5 papers in channels, the Netherlands with 2 in 2 channels, and Australia with 1 in single channel.

A clear standout is the 1991 publication in *Virology* on the expression of HPV 16 L1 and L2 proteins, which garnered a remarkable 774 citations, ranking it highest among all. Its high AoP of 35 years and a robust CGR of 22.11 indicates its foundational influence and continued relevance. This sets it apart as a seminal work in HPV vaccine research. The second and third-ranked papers published in *Journal of Virology* (1999) and *Vaccine* (2000) also reflect strong scientific contributions, with 357 and 255 citations, respectively. Their CGRs, although lower than the top-ranked paper, still reflect steady.

Citation momentum, suggesting sustained interest. Notably, the 2000 *Vaccine* paper has the lowest AoP (26) among the top three but still managed to accrue significant citations, showing the importance of its findings in more recent research developments.

A general trend emerges where most highly cited works (especially those with CGRs above 5.0) were published between 1991 and 2000, a period marked by key advancements in HPV virology and immunology. Several of these appeared in *Virology*, indicating the journal's central role in disseminating high-impact research in this domain. The recurring presence of *Journal of Virology* and *Virology* also hints at a concentrated scholarly ecosystem for HPV-related breakthroughs.

Table 5: Position in byline of authors.

Publications	Position in byline of authors								Total
	1st	2nd	3rd	4th	5th	6th	7th	9th	
Two-authored	2	12							14
Three-authored	1	2							3
Four-authored	6	1	3	2					12
Five-authored	1				3				4
Six-authored	2								2
Seven-authored	1					1			2
Nine-authored								1	1
Ten-authored								1	1
Eleven-authored		1	1						2
Twelve-authored							1		1
Total	13	16	4	2	3	1	1	2	42

Table 6: List of Collaborators of Zhou's Research Team.

Sl. No.	Co-author's names	TP	YFP	YLP	Time Span	P/Y
1.	Ian H Frazer (Future research partner)	40	1990	2011	21	1.95
2.	Xiao-Yi Sun (Classmate, Spouse and Research partner)	16	1990	2003	13	1.23
3.	GJ Fernando	5	1992	1999	8	0.63
4.	DJ Stenzel	4	1990	1993	4	1.00
5.	Kong Nan Zhao	3	1998	1999	2	1.50
6.	Lionel Crawford	3	1990	1992	3	1.00
7.	Shi Wen Peng	3	1996	1999	4	0.75
8.	Wen Jun Liu	3	1999	1999	1	3
9.	Geoffrey L. Smith	2	1990	1998	9	0.22
10.	Graham R Leggatt	2	1999	2009	11	0.18
11.	Li Fang Zhang	2	2000	2000	1	2
12.	M Williams	2	1999	1999	1	2
13.	Martin Müller	2	1995	1995	1	2
14.	Robert W Tindle	2	1993	1999	7	0.29
15.	Ying Mei Qi	2	1996	1998	3	0.67
16.	Fei Yun Zheng	1	2000	2000	1	2
17.	Jagadish Padmanabha	1	2000	2000	1	2
18.	Jie Qiang Lu	1	2000	2000	1	2
19.	Karen Malcolm	1	2000	2000	1	2
20.	Kylie Hengst	1	2000	2000	1	2
21.	Lian Lian Cai	1	2000	2000	1	2
22.	Qi Yu Bao	1	2000	2000	1	2
23.	Shao Chen	1	2000	2000	1	2
24.	A Bennet Jenson	1	1995	1995	1	1
25.	A Rahimpour	1	2009	2009	1	1
26.	Angel Alonso	1	1995	1995	1	1
27.	Barbara Murray	1	1999	1999	1	1
28.	CS McLean	1	1991	1991	1	1
29.	Davies H	1	1992	1992	1	1
30.	Denise A Galloway	1	1998	1998	1	1
31.	DS Park	1	1996	1996	1	1
32.	Hanswalter Zentgraf	1	1995	1995	1	1
33.	J Broom	1	2009	2009	1	1
34.	J Doorbar	1	1991	1991	1	1
35.	J Zhong	1	2009	2009	1	1
36.	JB Mesa	1	2002	2002	1	1
37.	Jerzy K Kulski	1	1998	1998	1	1
38.	John W Sadleir	1	1998	1998	1	1
39.	K Hengst	1	1996	1996	1	1

40.	K Louis	1	1994	1994	1	1
41.	L Gissmann	1	1995	1995	1	1
42.	Lia McLean	1	1990	1990	1	1
43.	Linda Dunn	1	1999	1999	1	1
44.	Luis Filgueira	1	1999	1999	1	1
45.	Lutz Gissmann	1	1995	1995	1	1
46.	M Evander	1	1996	1996	1	1
47.	Margaret Stanley	1	1990	1990	1	1
48.	Maria S Cicchini	1	1998	1998	1	1
49.	Michael Sharkey	1	1999	1999	1	1
50.	N Abdul Warif	1	2009	2009	1	1
51.	Neil Almond	1	1990	1990	1	1
52.	Nigel McMillan	1	1999	1999	1	1
53.	NX Fang	1	1999	1999	1	1
54.	Paul F. Lambert	1	2000	2000	1	1
55.	Paula Barnard	1	1999	1999	1	1
56.	Peter Manders	1	1999	1999	1	1
57.	Pirkko Heino	1	2000	2000	1	1
58.	R De Kluyver	1	2009	2009	1	1
59.	Ranjeny Thomas	1	1999	1999	1	1
60.	Richard J Cristiano	1	1995	1995	1	1
61.	S Fiorenza	1	2009	2009	1	1
62.	S Mattarollo	1	2009	2009	1	1
63.	S Peng	1	1998	1998	1	1
64.	SD Park	1	1992	1992	1	1
65.	Stephen R Kelsall	1	1998	1998	1	1
66.	U Hadis	1	2009	2009	1	1
67.	X Liu	1	2009	2009	1	1

In terms of productivity and aging, the AoP values for most papers hover around 2635 years, underscoring their longstanding contribution. However, some papers, despite older AoPs (e.g., Sl. No. 12 and 14), show lower CGRs (<2.5), suggesting that while they were impactful initially, their influence may be tapering or becoming niche. Conversely, works like the 1998 paper on CTL epitope delivery (Sl. No. 7) maintain a relatively high CGR (6.43), signifying a continued applicability in the field of immunotherapy. The presence of a US patent among the top 14 (Sl. No. 14) is particularly noteworthy. Though it ranks last in citations (50), its inclusion highlights the translational and commercial relevance of the research, indicating that scientific innovation extended beyond academic outputs into practical applications.

Overall, the data reflects a robust research output centered around HPV virology with sustained citation activity for core papers, particularly those published in the 1990s. The citation dynamics also suggest that early work on virus-like particles and capsid protein interactions laid the groundwork for later advancements in vaccine development and immunological strategies. This enduring scholarly interest, as evidenced by CGR values, confirms the foundational and translational impact of these publications across decades.

LIMITATIONS

Although this study presents a rigorously documented tribute through a bibliometric lens, it is subject to several limitations: Small dataset size: The analysis is based on a limited corpus of only 42 publications, which constrains the generalizability of the findings. Consequently, the application of bibliometric laws such as Lotka's and Bradford's to such a small, author-centric dataset (including co-authors) may be methodologically weak or potentially misleading.

Database bias: The study relies on selected databases whose coverage and indexing practices vary, introducing potential bias.

In the case of Zhou, a comprehensive publication record could not be obtained from a single authoritative profile. Instead, much of the dataset was reconstructed from the profile of his collaborator Ian H. Frazer via Google Scholar, along with supplementary sources such as PubMed.

Attribution uncertainty: Author name ambiguity (e.g., "J Zhou" or "Jian Zhou" or identical names) posed significant challenges in accurately identifying publications. To mitigate this, affiliations and co-authorship, particularly with Ian H. Frazer were used for verification, along with cross-checking across Google Scholar and PubMed. However, some degree of attribution error may persist.

Table 7: List of publication sources.

Sl. No.	Publication Sources	TP	%	FYP	LYP	Country
	Journal Articles [24, 57.14%]					
1.	Virology	12	28.58	1991	2000	USA
2.	Journal of General Virology	3	7.14	1990	1993	UK
3.	Journal of Virology	3	7.14	1994	1999	USA
4.	Vaccine	1	2.38	2000	2000	USA
5.	Clinical and Experimental Immunology	1	2.38	1999	1999	UK
6.	Immunological Reviews	1	2.38	1999	1999	USA
7.	Journal of Investigative Dermatology	1	2.38	2009	2009	Netherlands
8.	Journal of Leukocyte Biology	1	2.38	1993	1993	USA
9.	Virus Research	1	2.38	1999	1999	Netherlands
	Conference Papers [2, 4.76%]					
10.	Papillomavirus Workshop (Seattle, WA 1991).	1	2.38	1991	1991	USA
11.	Paper presented at the Offshore Technology Conference, Houston, Texas, May 1999.Offshore Technology Conference, Paper No. OTC-10782-MS	1	2.38	1999	1999	USA
	Book Chapter [1, 2.38%]					
12.	In Charles Lacey, ed. Papillomavirus reviews: current research on papillomaviruses. Leeds, Yorkshire, United Kingdom, University Press	1	2.38	1996	1996	UK
	Patents [15, 35.72%]					
13.	US Patent 5,993,821	1	2.38	1999	1999	USA
14.	US Patent 6,013,262	1	2.38	2000	2000	USA
15.	US Patent 6,489,141	1	2.38	2002	2002	USA
16.	US Patent 6,613,557	1	2.38	2004	2004	USA
17.	US Patent 6,846,671	1	2.38	2005	2005	USA
18.	US Patent 6,867,033	1	2.38	2005	2005	USA
19.	US Patent 7,169,585	1	2.38	2007	2007	USA
20.	US Patent 7,229,761	1	2.38	2007	2007	USA
21.	US Patent 7,476,389	1	2.38	2009	2009	USA
22.	US Patent 7,741,079	1	2.38	2010	2010	USA
23.	US Patent 7,939,082	1	2.38	2011	2011	USA
24.	US Patent App. 09/899,954	1	2.38	2002	2007	USA
25.	US Patent App. 10/305,633	1	2.38	2002	2002	USA
26.	US Patent App. 11/455,236	1	2.38	2007	2007	USA
27.	Australian Patent AUPK732291	1	2.38	199.1	1991	Australia
		42	100			

Table 8: Top 14 scholarly publications with citation received (≥ 50).

Sl. No.	Title of Papers	Publication Channels (Year)	Total Citation	Rank	AoP	CGR
1.	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)	774	1	35	22.11
2.	Papillomavirus capsid protein expression level depends on the match between codon usage and tRNA availability	Journal of Virology (1999)	357	2	27	13.22
3.	HPV6b virus like particles are potent immunogens without adjuvant in man	Vaccine (2000)	255	3	26	9.81
4.	Synthesis and assembly of infectious bovine papillomavirus particles *in vitro*	Journal of General Virology (1993)	181	4	33	5.48
5.	Interaction of Human Papillomavirus (HPV) type 16 capsid proteins with HPV DNA requires an intact L2 N-terminal sequence	Journal of Virology (1994)	180	5	32	5.63
6.	Papillomavirus virus-like particles can deliver defined CTL epitopes to the MHC class I pathway	Virology (1998)	180	5	28	6.43
7.	Potential strategies utilised by papillomavirus to evade host immunity	Immunological Reviews (1999)	170	6	27	4.86
8	Identification of the nuclear localization signal of human papillomavirus type 16 L1 protein	Virology (1991)	142	7	35	4.06
9.	DNA packaging by L1 and L2 capsid proteins of bovine papillomavirus type 1	Virology (1998)	118	8	28	4.21
10.	Expression, purification and immunological characterization of the transforming protein E7, from cervical cancer-associated human papillomavirus type 16	Clinical and Experimental Immunology (1999)	83	9	27	3.07
11.	The vaccinia virus K2L gene encodes a serine protease inhibitor which inhibits cell-cell fusion	Virology (1992)	73	10	34	2.15
12.	Epithelial cells display separate receptors for papillomavirus VLPs and for soluble L1 capsid protein	Virology (1996)	71	11	30	2.37
13.	Sequences required for the nuclear targeting and accumulation of human papillomavirus type 6B L2 protein	Virology (1995)	58	12	31	1.87
14.	Recombinant papilloma virus L1	US Patent 6,013,262 (2000)	50	13	26	1.92

Citation noise in Google Scholar: Google Scholar's inclusion of non-scholarly or inconsistently indexed materials may introduce noise into citation counts. In the absence of a dedicated author profile and given the limited coverage in PubMed, citation data were largely derived from publications co-authored with Ian H. Frazer, which may affect accuracy.

Constraints of author-centric analysis: A primary focus on the author may overlook broader contextual dimensions such as institutional affiliations, thematic trends, and collaborative networks. These challenges highlight the need for universally accepted author identification and cataloguing standards (e.g., AACR2R, RDA), along with robust disambiguation protocols and the inclusion of distinguishing identifiers to ensure accurate and comprehensive retrieval of an individual's scholarly output. Author name ambiguity causes complexity in searching for a particular author.

CONCLUSION

The analysis highlights that,

- **Publication Output:** Zhou produced 42 publications on HPV, including 26 papers during 19901999 and 16 papers published posthumously, indicating lasting scholarly influence.
- **Collaboration Pattern:** All publications were co-authored, with Ian H. Frazer being the primary collaborator (40 joint papers over 21 years, averaging 1.95 papers annually) and Xiao-Yi Sun contributing to 16 papers.

- **Type and Venue of Publications:** A majority (58.14%) of his works were journal articles, with 12 papers published in *Virology*, highlighting the journal's importance in disseminating his research.
- **Most Influential Work:** His 1991 paper in *Virology* stands out as the most cited, accumulating 774 citations, supported by a high AoP (35 years) and CGR (22.11), marking it as a seminal contribution to HPV vaccine development.
- **Research Activity Over Time:** Zhou published consistently at 23 papers per year, reaching his peak productivity during 19951999, when he produced 14 papers.
- **Authorship Patterns:** Two authored and three-authored publications were most common (14 and 12 papers, respectively). Zhou held prominent authorship positions, appearing 13 times as first author and 16 times as second author.
- **Authorship Distribution Metrics:** The values CC=0.63, CI=4.56, MCC=4.65, and DC=1 indicate moderate conformity and a balanced, internally consistent distribution of authorship.
- **Overall Impact:** The evidence highlights Zhou's significant and lasting contribution to HPV research, characterized by strong collaborations, high impact publications, and foundational work shaping advancements in papillomavirus biology and vaccine research.

Jian Zhou was a brilliant medical scientist whose work helped create the first vaccine for Human Papillomavirus (HPV), a major cause of cervical cancer. Ian Frazer, a doctor from Scotland, had joined the University of Queensland in 1985 and was trying to develop an HPV vaccine but struggled because the virus couldn't be grown in the lab. His luck changed when he met Zhou, an expert in gene cloning, who found a way to copy the virus's outer proteins using a harmless virus as a model. This breakthrough led to the development of the HPV vaccine. Sadly, Zhou passed away in 1999 at just 42, due to hepatitis he had contracted in his youth. Frazer carried on their work, and today the vaccine is recommended by the World Health Organization and used in many countries to protect young women aged 9 to 25 years old. The University of Queensland has also made it more accessible by waiving royalties in 72 low-income countries (epo.org, n.d.). The teamwork between Zhou and Frazer is a great example of how global scientific collaboration can lead to lifesaving medical discoveries. According to Frazer, "Dr Zhou was a great collaborator, clinician scientist, and friend, whose work had a huge impact on health globally" (epo.org, n.d.).

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ABBREVIATIONS

CoA: Co-author; **DC:** Degree of Collaboration; **SAP:** Single-authored; **FYP:** First Year of Publication; LYP**:** Last Year of Publication; **TP:** Total Paper; **AA:** Author's Biological Age; **CP:** Cumulative Percentage; **P/Y:** Paper per Year; **PPA:** Paper Productive Age; **MAP:** Multi-authored Paper; **APC:** Annual Paper Count; **2A:** Two-authored Paper; **TA:** Total Authors; **CGR:** Citation Growth Rate; **AoP:** Age of Papers; **Y(O):** Number of Observed Authors; **Y(E):** Number of Expected Authors; **1st:** First Position; **AAHMS:** Australian Academy of Health and Medical Sciences; **epo.:** European Patent Office; **NIH:** National Institutes of Health (USA); **WHO:** World Health Organization.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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