Bibliometric Trend Analysis: Turner Syndrome in Childhood

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Abstract

Turner Syndrome is a genetic disorder in females caused by the partial or complete absence of one X chromosome, significantly impacting neuropsychological development during childhood. Using a bibliometric approach, this study aims to map the global research landscape on childhood TS from 1960 to 2024. Data were sourced from the Scopus database and analyzed using Publish or Perish, Microsoft Excel, and VOSviewer. Results indicate fluctuating publication trends, with a peak in 2005, driven by advancements in genetic diagnostics such as FISH and the Human Genome Project. The United States leads in research output and international collaboration. Keyword analysis identified six main research clusters: quality of life, cognitive function, metabolic disorders, puberty, and early diagnosis. However, gaps remain in research concerning the psychosocial and emotional support needs of TS patients. This study recommends a multidisciplinary approach and further exploration of socio-emotional aspects to enhance interventions and improve the quality of life for children with Turner Syndrome, especially in developing countries like Indonesia, where epidemiological data and public awareness remain limited.

Keyword : Neuropsychology; Turner Syndrome; Childhood; Bibliometric

Abstrak

Turner Syndrome merupakan kelainan genetik pada perempuan akibat hilangnya sebagian atau seluruh kromosom X, yang berdampak signifikan pada aspek neuropsikologis dan perkembangan anak. Studi ini bertujuan untuk memetakan lanskap penelitian global terkait TS pada masa kanak-kanak sejak 1960 hingga 2024 melalui pendekatan bibliometrik. Data diperoleh dari basis data Scopus dan dianalisis menggunakan Publish or Perish, Microsoft Excel, dan VOSviewer. Hasil menunjukkan fluktuasi publikasi yang signifikan, dengan puncak tertinggi pada tahun 2005, yang dipengaruhi oleh kemajuan teknologi genetika seperti FISH dan Human Genome Project. Amerika Serikat mendominasi kontribusi penelitian, baik dalam jumlah publikasi maupun kolaborasi internasional. Analisis kata kunci mengidentifikasi enam klaster fokus penelitian, seperti kualitas hidup, aspek kognitif, gangguan metabolik, serta pubertas dan diagnosis dini. Namun, ditemukan kesenjangan dalam topik yang berkaitan dengan aspek psikososial dan dukungan emosional penderita TS. Studi ini merekomendasikan perlunya pendekatan multidisipliner dan eksplorasi lanjutan pada aspek sosial-emosional untuk meningkatkan intervensi serta kualitas hidup anak dengan Turner Syndrome, khususnya di negara-negara berkembang seperti Indonesia yang masih memiliki keterbatasan data epidemiologis dan kesadaran publik yang rendah.

Kata kunci : Neuropsikologi; Sindrom Turner; Masa Kanak-Kanak; Bibliometrik

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Introduction

The development of neuropsychological research related to Turner Syndrome (TS) is crucial to understand, particularly in childhood. Turner Syndrome is caused by the partial or complete loss of one X chromosome in females, which significantly impacts neuropsychological development in children. Children with TS often face various cognitive difficulties, including impairments in executive functioning, visual memory, and visuospatial abilities (Mauger et al., 2018; Rezaie et al., 2009; Hutaff-Lee et al., 2019; Kesler et al., 2004).

Globally, Turner Syndrome has a prevalence of approximately 50 cases per 100,000 females (Gravholt et al., 2024). In Indonesia, epidemiological data on this condition remain limited. Research by Purwana et al. (2013) recorded 23 TS cases at Cipto Mangunkusumo Hospital (RSCM) between 2000 and 2012, while Arimbawa et al. (2016) reported 20 similar cases at the same hospital. Due to limited public awareness, many individuals with TS may go undiagnosed. The Indonesian Pediatric Society estimated there would be around 59,000 TS cases in 2010. Based on the 2020 national census, with a female population of 133.54 million, TS cases are projected to increase to 67,000.

Children with TS exhibit distinctive neuropsychological profiles, including attention deficits and executive function impairments, which can impact both academic performance and social competence (Hutaff-Lee et al., 2019). The magnitude of executive dysfunction in children with TS ranges from small to large, depending on the type of task assessed (Mauger et al., 2018). Research on childhood TS is highly relevant in Indonesia, as the condition affects multiple aspects of female child development and well-being.

Research on Turner Syndrome in Indonesia remains limited, with low public awareness, suboptimal early diagnosis, and restricted access to medical and psychosocial interventions. Children with TS often experience learning difficulties and social challenges, yet educational support systems in Indonesia remain inadequate. Further research can enhance early detection, clinical intervention strategies, and more inclusive education policies, ultimately improving the quality of life for affected individuals.

The true prevalence of TS in Indonesia may be higher than estimated, as many cases are not diagnosed until adulthood. Studies show that girls with TS are often diagnosed late, resulting in serious complications such as reproductive and cardiac health issues (Trisnawan et al., 2022; Viuff et al., 2021). This delay is frequently due to a lack of awareness among parents and medical professionals about early TS symptoms, such as stunted growth and physical abnormalities (Green et al., 2014). Neuropsychological and psychosocial findings indicate that children with TS may struggle with executive functioning, anxiety, depression, and social interaction. However, some individuals demonstrate good social adaptability, mainly when supported by early intervention and strong family involvement (Hong et al., 2020; Green et al., 2014; Viuff et al., 2021). Programs that involve families in the care process are essential, as family support contributes to successful treatment and ongoing monitoring (Hafiar et al., 2023).

Bibliometric analysis is commonly used in various scientific disciplines and focuses on quantitative studies (Heersmink et al., 2011). In this research, bibliometric analysis was conducted using VOSviewer software with data from the Scopus database. This study aims to examine the research landscape related to Turner Syndrome in childhood from 1960 to 2024. The year 1960 was chosen as the starting point, marking the early period of TS research in the Scopus database. This timespan allows for a comprehensive analysis of publication trends, citation patterns, and the geographic distribution of TS research over time. The research questions addressed in this study are as follows:

1. What are the current publication trends related to Turner Syndrome in childhood?
2. What are the citation trends in research on Turner Syndrome in childhood?
3. What is the geographical distribution of publications and the patterns of international collaboration in TS research?
4. What are the dominant research focuses in studies on Turner Syndrome in childhood?

This study aims to explore and analyze the trends in literature related to Turner Syndrome in childhood, with a specific focus on neuropsychological aspects such as cognitive function (including memory, attention, and problem-solving abilities), visuospatial skills, and socio-emotional development, including emotional regulation, anxiety, and social interaction. The analysis seeks to identify areas requiring further research and clinical attention, and to provide a foundation for developing more effective intervention strategies for children with TS. By identifying research trends and needs in this field, this study contributes to developing health policies and educational programs to increase awareness of TS among the general public and medical professionals. This research is relevant and urgently needed to improve the understanding and management of Turner Syndrome in Indonesia.

Research Methods

The research methodology outlines how the study was conducted, describing the procedures including research design, target population (population and sample), data collection techniques, and data analysis methods. It may also include an explanation of materials and tools used, as well as the time, location, and experimental design. Bibliometric analysis examined research trends in scientific articles, books, and papers (Heersmink et al., 2011). In this study, the researcher utilized bibliometric analysis using journal data sourced from the Scopus database. The bibliometric analysis was conducted through the following steps:

1. Identification
   Keywords were entered into the search bar of the Scopus database using the following terms: ("Turner syndrome" OR "Turner syndrome disorder") AND ("childhood" OR "childhood development"). This initial search resulted in 602 related scientific articles.
2. Screening
   Inclusion criteria were applied to limit the results to only journal articles and conference papers written in English, with subject areas focused on psychology, neuroscience, medicine, biochemistry, genetics, and molecular biology. This filtering process yielded 90 relevant articles.

3. Eligibility
   Each article was reviewed at this stage to ensure it specifically addressed Turner Syndrome during childhood. After applying this criterion, 20 articles were deemed eligible for inclusion.
4. Inclusion
   The 20 selected articles that passed through the previous stages were then subjected to bibliometric analysis.

While VOSviewer was the primary software used for bibliometric visualization, Microsoft Excel was also utilized to manage and coordinate the exported data. Initially, data from Scopus was exported in CSV format and processed in Excel. Then, the Publish or Perish software was used to calculate the number of publications and citations per year and determine the h-index and g-index.
VOSviewer was subsequently used to analyze:

1) Geographical distribution of research publications by country,
2) Key research foci and emerging topics,
3) Author collaboration networks and publication trends.

This methodological approach allowed for a comprehensive mapping of the literature landscape concerning Turner Syndrome in childhood from 1960 to 2024.

Result

Based on the data collection process regarding publications on Turner Syndrome in children, 20 publications from the period 1960 to 2024 were identified in accordance with the established inclusion criteria. Once the raw data were obtained, a bibliometric analysis was conducted to examine trends in publication, citation patterns, country distribution, journals, and research focus.

1. Research Question 1: What are the publication trends related to Turner Syndrome in childhood?

The results of the bibliometric analysis reveal the distribution of publications on Turner Syndrome in childhood, as illustrated in the figure below. As shown in Figure 1, research on Turner Syndrome in childhood has fluctuated over the past 64 years, from 1960 to 2024, with annual publication numbers ranging between 1 and 17 papers. A significant increase occurred in 2005, marked by a peak of 17 publications, followed by a decline to 2 publications in 2010. According to a study by Levsky and Singer (2003), this surge was likely influenced by rapid advancements in fluorescence in situ hybridization (FISH) techniques in the early 2000s. FISH, a tool widely used for identifying genetic abnormalities, enabled more precise diagnoses and deeper investigations into Turner Syndrome.

Similarly, literature reviews suggest that the Human Genome Project (HGP) published in 2001 profoundly impacted subsequent studies concerning human genome structure and function (Naidoo et al., 2011). The HGP, an international initiative to map and sequence human DNA, motivated researchers to explore various genetic conditions, including Turner Syndrome. In contrast, the significant decline in 2010 (only 2 publications) may be attributed to a shift in research focus from single-gene disorders toward more complex diseases involving gene–environment interactions (Manolio et al., 2009). Moreover, as a rare genetic disorder,

Turner Syndrome presents challenges related to data collection and participant recruitment due to its low prevalence (Gravholt & Stochholm, 2006).

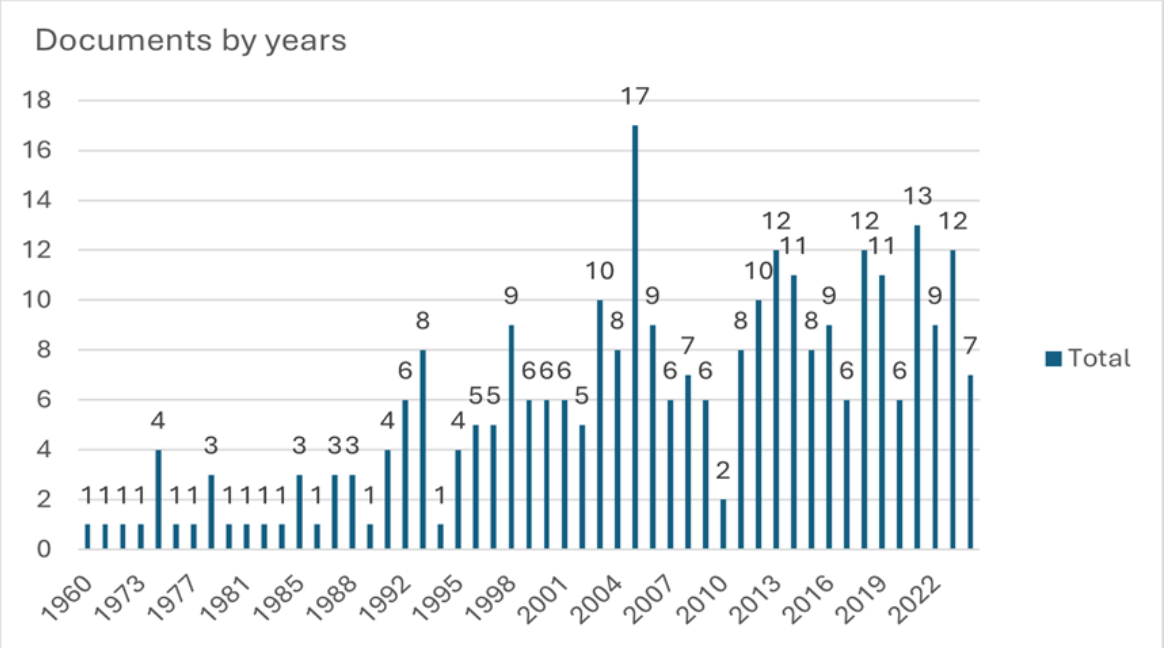

Figure 1. Publication Trends by Year of Publication

2. Research Question 2: What are the citation trends for Turner Syndrome publications in childhood?

Table 1 presents citation trends for publications related to Turner Syndrome in childhood from 2014 to 2024**.** Similar to the publication trend analysis, 292 citations were examined and categorized by publication year. The analysis includes metrics such as Total Citations (TC)**,** Number of Cited Publications (NCP)**,** h-index**,** and g-index, as summarized in Table 1 below.

Tabel 1. Citation Analysis of Publications

Years	TP	TC	NCP	h	g
2024	7	9	3	1	3
2023	12	12	5	2	12
2022	9	51	6	3	7
2021	13	143	11	8	11
2020	6	36	5	4	6
2018	12	163	12	8	12
2017	6	882	5	4	6
2016	9	114	8	6	9
2015	8	153	8	6	8
2014	11	251	10	9	11

2013	12	359	11	10	12
2012	10	227	8	7	10
2011	8	312	5	7	8
2010	2	110	2	2	2
2009	6	127	5	3	6
2008	7	391	7	7	7
2007	6	1151	6	5	6
2006	9	156	9	6	9
2005	17	601	10	12	17
2004	8	307	8	7	8
2003	10	263	10	7	10
2002	5	164	5	5	5
2001	6	122	6	6	6
2000	6	333	5	5	6
1999	6	379	6	6	6
1998	9	865	8	8	9
1997	5	243	5	3	5
1996	5	462	5	5	5
1995	4	167	4	4	4
1994	1	10	1	1	1
1993	8	281	7	6	8
1992	6	145	5	5	6
1991	4	87	4	3	4
1990	1	0	0	0	0
1989	-	-	-	-	-
1988	3	192	3	3	3
1987	3	63	3	3	3
1986	1	22	1	1	1
1985	3	136	3	3	3
1984	1	43	1	1	1
1983	-	-	-	-	-
1982	1	2	1	1	1

1981	1	2	1	1	1
1980	1	25	1	1	1
1979	-	-	-	-	-
1978	3	122	2	1	3
1977	1	31	1	1	1
1976	-	-	-	-	-
1975	1	29	1	1	1
1974	4	149	4	2	4
1973	1	127	1	1	1
1972	-	-	-	-	-
1971	1	321	1	1	1
1970	-	-	-	-	-
1969	-	-	-	-	-
1965	-	-	-	-	-
1964	-	-	-	-	-
1963	-	-	-	-	-
1962	-	-	-	-	-
1961	1	6	1	1	1
1960	1	6	1	1	1
Total	276	10.352	241	204	272

Notes. TP=total publication, TC=total citations, NCP=number of cited publication, h=h-index, g=g-index.

Table 1 indicates that the highest number of publications occurred in 2005, with a Total Publications (TP) value of 17. However, in terms of citation volume, publications from 2007 received the highest number of citations, totaling 1,151 citations. Meanwhile, the highest Number of Cited Publications (NCP) was recorded in 2018, with a value of 12. Publications from 2005 had the strongest scholarly impact compared to other years, achieving an h-index of 12 and a g-index of 17. This suggests that a considerable number of articles published in that year have been frequently cited by other researchers, reflecting their significant contribution to the development of research on Turner Syndrome in childhood. Table 2 presents the top five most-cited publications from 2005, highlighting the articles that have had the greatest influence on subsequent research in this area.

Research conducted by Sutton et al. (2005) highlights the numerous challenges individuals with Turner Syndrome face throughout their lives. The study emphasizes four key aspects: physical developmental issues, cardiovascular complications, reproductive difficulties, and significant psychosocial impact. In terms

of physical development, Turner Syndrome is characterized by short stature and abnormal sexual development. Cardiovascular issues, including congenital heart defects and hypertension, are also significant concerns that require continuous monitoring and early intervention. Infertility presents a substantial challenge for women with Turner Syndrome, although some may experience spontaneous menstruation or even pregnancy. From a psychosocial perspective, individuals may struggle with low self-esteem and social integration, particularly due to perceived physical differences from an early age. Psychological support and tailored educational approaches are thus crucial in assisting individuals with Turner Syndrome navigate these lifelong challenges.

Table 2. Most Cited Articles Published in 2005

Author(s)	Title	Journal	Citations
(Sutton et al., 2005)	Turner syndrome: Four challenges across the lifespan.	American Journal of Medical Genetics, Part A.	105
(Massa et al., 2005)	Trends in age at diagnosis of Turner syndrome.	Archives of Disease in Childhood.	104
(Ross et al., 2005)	The phenotype of short stature homeobox gene (SHOX) deficiency in childhood: Contrasting children with Leri-Weill dyschondrosteosis and turner syndrome.	Journal of Pediatrics.	71
(Dhooge et al., 2005)	Otologic disease in Turner syndrome.	Otology and Neurotology.	56
(Kiliç et al., 2005)	Depression, levels of anxiety and self-concept in girls with Turner's syndrome.	Journal of Pediatric Endocrinology and Metabolism.	48

The findings also reveal a positive trend in early diagnosis of Turner Syndrome, underscoring the ongoing need to raise awareness and enhance early detection strategies to optimize treatment and management (Massa et al., 2005). The study stresses the importance of early diagnosis to enable the timely initiation of growth hormone therapy, which is essential for promoting physical development and inducing puberty appropriately. It also recommends cytogenetic analysis for girls with short stature as a screening tool for early identification of Turner Syndrome. Early diagnosis can also help prevent the development of comorbidities such as hypertension and hearing loss, both of which significantly affect quality of life.

3. Research Question 3: What is the geographical distribution of publications and the collaboration patterns among countries in Turner Syndrome research during childhood?

Figure 2 displays the geographic distribution of publications based on the country of origin of the authors, spanning from 1960 to 2024. The researchers set a threshold of at least five documents, meaning that only countries with at least five relevant publications are visualized.

Verify selected countries

Selected	Country	Documents	Citations	Total link strength
☑	united states	83	4437	9214
☑	united kingdom	35	1949	5474
☑	germany	26	1731	4065
☑	netherlands	23	1569	5571
☑	denmark	18	1972	5237
☑	italy	18	1201	4237
☑	france	17	1235	4615
☑	sweden	17	1478	4342
☑	belgium	12	1319	3807
☑	poland	10	900	3212
☑	japan	10	131	638
☑	canada	9	980	2982
☑	spain	9	92	931
☑	turkey	9	144	538
☑	switzerland	8	318	709
☑	israel	7	147	1045
☑	australia	6	893	3214
☑	greece	5	866	3327
☑	finland	5	861	2885
☑	brazil	5	38	483

Figure 2. Geographic Distribution of Publications

The figure shows that the United States leads in the number of publications related to Turner Syndrome in childhood, with 83 publications in total. Additionally, the United States ranks first in terms of citation count, with 4,437 citations. According to the All of Us Research Program Genomics Investigators (2024), the United States through its All of Us program is actively conducting genetic research to understand the biological basis of human diseases. The All of Us program, led by the National Institutes of Health (NIH), seeks to gather genomic and health data from over one million individuals nationwide to advance precision medicine and genetic understanding, including conditions like Turner Syndrome.

Figur 3. based on the VOSviewer visualization, an illustration of international research collaboration on Turner Syndrome in childhood is presented, where each circle represents the countries involved. The United States has the largest circle diameter, indicating that this country has the highest level of collaboration compared to the other 19 countries. Referring to the interpretation of the two figures above, the United States has made the most significant contribution to the study of Turner Syndrome in childhood, with the most publications and extensive collaboration with other countries.

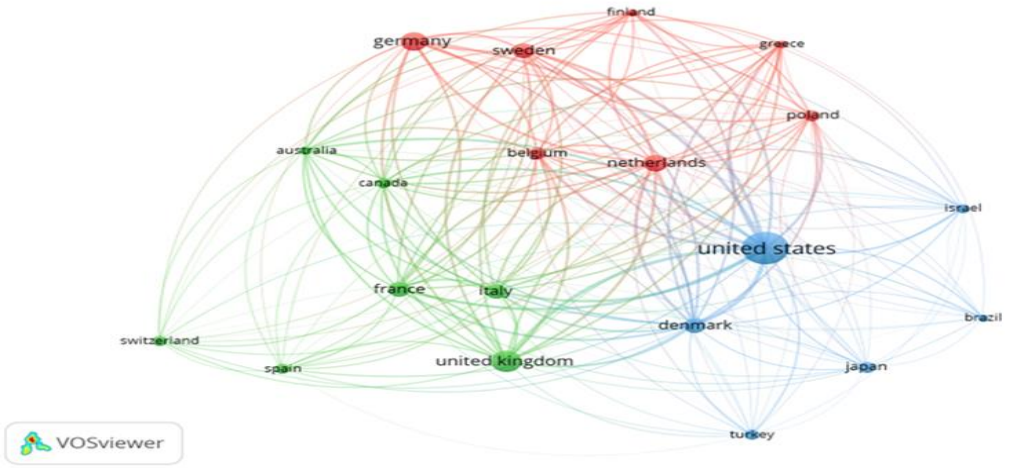

Figure 3. Patterns of International Collaboration

4. Research Question 4. Focus of Research on Turner Syndrome in Childhood

Figure 4 shows the research focus on Turner Syndrome in childhood. The illustration was generated using the VOSviewer application with a threshold of 5. This means that only keywords appearing in at least 5 different documents are displayed. The larger the circle's diameter, the more frequently that keyword appears. After applying the threshold, 30 keywords remain from a total of 334 keywords, as shown in Figure 5 below.

Based on the figure above, six clusters group keywords by color. The purpose of clustering is to differentiate research focuses. 1) The first cluster (red) consists of 8 items, with the largest circles for quality of life, cognition, and psychological aspects. 2) The second cluster (green) includes 7 items, with the largest circles for karyotype, obesity, and diabetes mellitus. 3) The third cluster (dark blue) consists of 6 items, and it is dominated by Turner syndrome, heredity, and chromosome analysis. 4) The fourth cluster (yellow) has four items, the largest of which are puberty, growth disorder, and delayed puberty. 5) The fifth cluster (purple) contains 3 items, with childhood, age, and disorders of sex development as the most prominent. 6) The sixth cluster (light blue) includes 2 items, early diagnosis and cholesterol, with the largest circles. These six research focuses may be a reference for future researchers in determining relevant study topics.

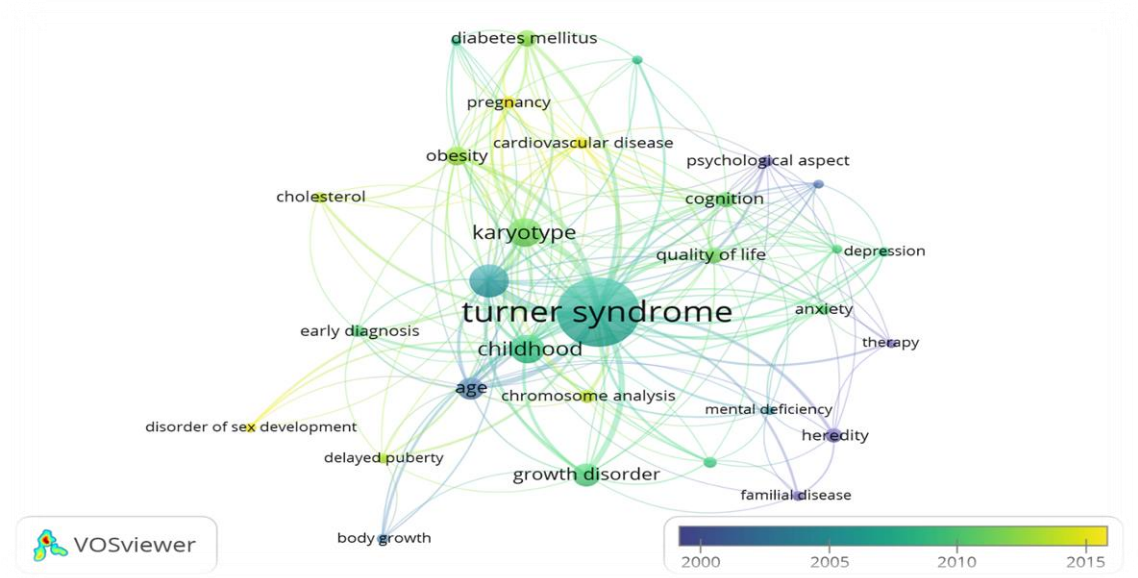

Figure 4. Co-occurrence of Keywords (Threshold ≥ 5)

The interrelation between keywords can be seen in the visualization in Figure 5. These connections serve as a guide to identifying the novelty of related studies. In other words, if a keyword is not connected to others, this indicates a gap and potential for new research. Turner Syndrome, although the most cited keyword, is not directly connected to the psychological aspect or social psychology. This gap could offer opportunities for future research to explore these aspects more deeply

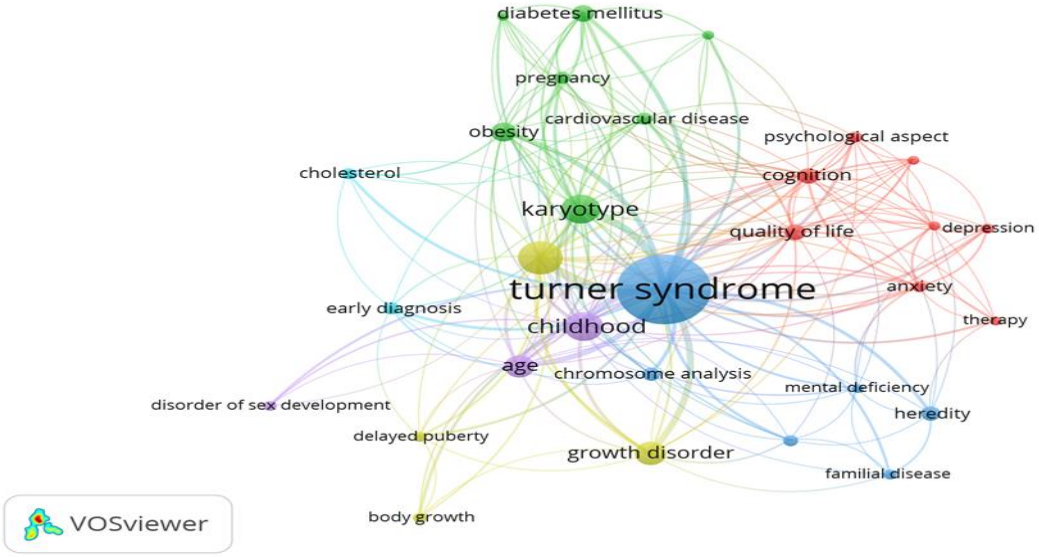

Figure 5. Research Novelty

Figure 5 illustrates the novelty of research related to these keywords. The image contains several color elements. Blue indicates keywords used between 2000 and 2005, green represents those used around 2010, and yellow shows those used more recently.

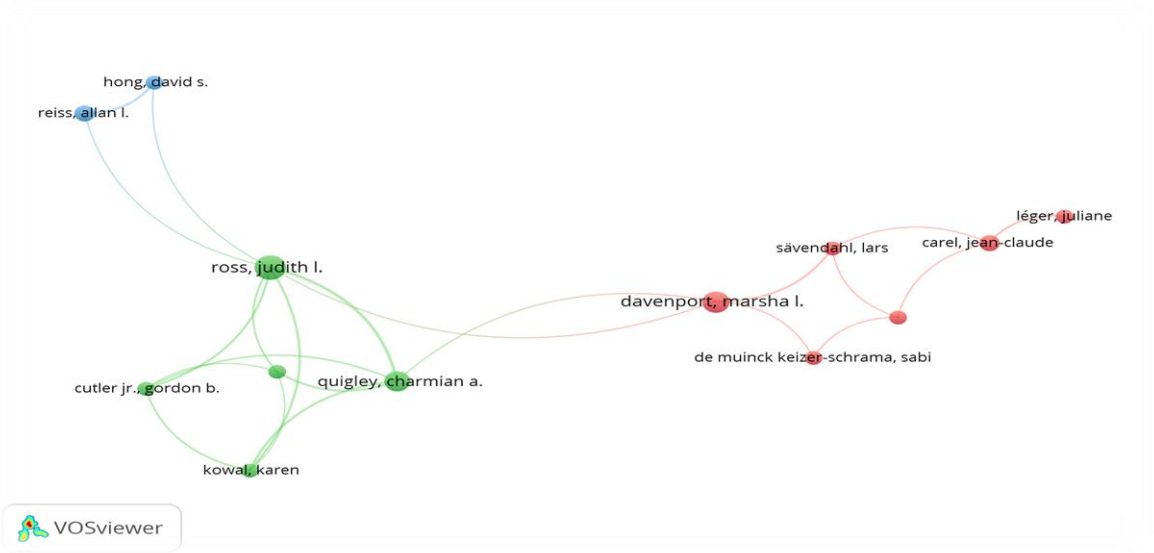

Figure 6. Author Visualization

Figure 6 presents the network of authors who have published studies related to Turner Syndrome in childhood, divided into three clusters: 1)The first cluster (red) consists of 5 authors, 2) The second cluster (green) includes 4 authors, 3)The third cluster (blue) contains 2 authors.

Discussion

1. Research Development on Turner Syndrome is Most Prevalent in the United States

According to the *All of Us Research Program Genomics Investigators* (2024), the United States is vigorously conducting genetic research through the *All of Us* program. This initiative, led by the National Institutes of Health (NIH), aims to understand the genetic foundations contributing to human diseases by collecting data from over one million individuals across the U.S.

There was a significant increase in Turner Syndrome-related publications in 2005, with 17 publications, followed by a sharp decline to only 2 in 2010. Research by Levsky and Singer (2003) indicated that the development of Fluorescence In Situ Hybridization (FISH) techniques rapidly advanced in the early 2000s. FISH, a technique used to diagnose genetic disorders, enabled researchers to identify and study Turner Syndrome more deeply.

A literature review also shows that *the Human Genome Project* (HGP), launched in 2001, significantly impacted subsequent research on the structure and function of the human genome (Naidoo et al., 2011). The HGP was an international effort to map and sequence human DNA. The release of its draft in 2001 inspired a surge in genetic studies, including investigations into Turner Syndrome. However 2010, a noticeable decline occurred with only two related publications. This has been predicted to result from a shift in research focus from single gene disorders to more complex diseases involving interactions between genetics and the environment (Manolio et al., 2009). Additionally, since Turner Syndrome is a rare genetic disorder with low prevalence, data collection and subject recruitment have posed challenges for researchers (Gravholt & Stochholm, 2006).

2. Key Research Findings from 2005

Research conducted by Sutton et al. (2005) highlighted multiple challenges individuals with Turner Syndrome face throughout their lives. The study emphasized four main areas: physical developmental issues, cardiovascular complications, reproductive difficulties, and significant psychosocial impacts.

Physically, Turner Syndrome is marked by short stature and abnormal sexual development. Cardiovascular risks, such as heart malformations and hypertension, require special attention. Reproductive issues like infertility present significant obstacles for individuals with TS, although some may experience spontaneous menstruation or pregnancy. Psychosocially, the syndrome may result in lower self-esteem and challenges in social relationships, often due to visible physical differences from an early age. Thus, psychological support and proper education are essential to help individuals navigate these challenges.

3. Early Diagnosis and Clinical Implications

Research by Massa et al. (2005) not only illustrated positive trends in early diagnosis of Turner Syndrome but also stressed the importance of raising awareness and enhancing early detection to optimize treatment and management. The study emphasized the need for early growth hormone therapy initiation to promote optimal growth and timely pubertal induction. It also recommended cytogenetic analysis for short-stature girls to ensure early TS detection. Early diagnosis can help

prevent comorbidities such as hypertension and hearing problems, which could impact quality of life.

4. Psychological and Cognitive Aspects

Turner Syndrome affects both physical and psychological conditions. As seen in Cluster 1, research themes on TS often involve quality of life, cognition, and psychological aspects. A study by Yusof et al. (2023) found that although individuals with TS may experience body image issues, many report having a good quality of life comparable to the general population. Despite this, they often face high levels of anxiety in social interactions, which poses challenges in social life.

Cognitive profiles that differ from the general population influence these social and psychological difficulties. Females with TS often struggle with visual and spatial tasks, though they generally possess strong verbal abilities. This leads to a significant discrepancy between verbal and non-verbal IQ scores. Moreover, symptoms of ADHD and autism spectrum disorder are found at higher rates in individuals with TS compared to the general population (Bjorlin Avdic et al., 2023).

5. Genetic and Metabolic Factors

Cluster 2 includes frequently discussed themes such as *karyotype*, *obesity*, and *diabetes mellitus*. These themes relate to the causes and effects of TS. Turner Syndrome is caused by a partial or complete loss of one X chromosome, leading to 45 chromosomes instead of the usual 46. Individuals with TS are at high risk of developing chronic conditions like diabetes. The physical abnormalities associated with TS also often lead to weight gain and obesity (Yoon et al., 2023).

6. Diagnosis and Clinical Characteristics

Cluster 3 includes keywords such as *cholesterol*, *early diagnosis*, *chromosome analysis*, *familial disease*, *mental deficiency*, and *heredity*. These themes describe diagnostic processes, clinical characteristics, and the impact of TS. Early diagnosis is crucial to ensure prompt intervention and support. In most cases, TS is not diagnosed until after age five due to a lack of early screening and public awareness, highlighting the need for early detection strategies (Apperley et al., 2018).

According to the Mayo Clinic (2022), early diagnosis can be achieved through chromosome analysis using a blood sample or prenatal ultrasound. TS is not hereditary; it typically occurs as a random event during reproduction due to an incomplete set of chromosomes (Kikkeri & Nagalli, 2023). TS is not directly associated with intellectual disability. While most individuals have normal intelligence, they often struggle with spatial concepts, memory, math, and attention. In addition to diabetes, individuals with TS are also at risk for cholesterol-related disorders. Research by Blaszczyk et al. (2023) found elevated cholesterol levels in adolescents with TS, linked to increased cortisol levels, potentially contributing to cardiovascular disease risk (Savas et al., 2019).

7. Pubertal and Growth Concerns

Cluster 4 addresses *puberty*, *growth disorder*, *body growth*, and *delayed puberty*, highlighting critical clinical issues in TS. Meyer et al. (2015) showed that short stature and delayed puberty in TS result from SHOX gene deficiency and

underdeveloped or absent ovaries (gonadal dysgenesis). This cluster underscores the importance of managing growth and pubertal issues in children with TS.

8. Childhood and Sexual Development Disorders

Cluster 5 focuses on *childhood*, *age*, and *disorders of sex development*, reflecting the clinical and psychosocial complexity in managing TS from early life. Childhood is crucial for detecting early clinical signs such as short stature and delayed puberty. Early diagnosis facilitates effective clinical treatment and supports psychosocial adjustment related to gender identity and self-perception (Lee et al., 2016). A holistic approach integrating biological and age-related developmental factors is essential in understanding individuals with TS.

9. Metabolic Risk and Early Intervention

Cluster 6 highlights the relationship between early diagnosis and metabolic issues such as cholesterol levels in individuals with TS. Valencia et al. (2011) showed that lipid disorders can begin in childhood, even before puberty. These findings support the importance of monitoring cholesterol and lipid profiles in children with TS to prevent future cardiovascular complications. Therefore, this cluster emphasizes the critical need for early detection and preventive intervention to reduce metabolic risks associated with Turner Syndrome.

Conclusion

The analysis results indicate significant fluctuations in the number of publications from 1960 to 2024, with the highest peak occurring in 2005. This surge has been driven by advancements in diagnostic techniques and genetic research, which attracted increased scholarly attention to Turner Syndrome. In terms of impact, publications from 2005 not only recorded the highest volume and demonstrated exceptional citation rates.

This study has contributed significantly to advancing knowledge regarding Turner Syndrome and developing more effective interventions for affected children. Geographical distribution shows that the United States dominates publication output, reflecting its prominent role in genetic and neuropsychological research. The high citation count of U.S.-based publications highlights their substantial influence on the global research landscape. Keyword analysis reveals that the research focus is clustered into several major themes, including quality of life**,** cognition, and psychological aspects**.** Although a wide range of aspects of Turner Syndrome have been addressed, there remains a research gap concerning its psychosocial impact and the necessary support systems for individuals with this condition.

Recommendations

This research gap suggests that despite numerous studies, certain areas remain underexplored, particularly those related to the emotional and social impacts on children with Turner Syndrome. Therefore, further research is strongly recommended to develop a more integrated and in-depth understanding of the challenges faced by these individuals. Future studies are encouraged to explore less-addressed topics, such as social interaction**,** community support, and the long-term effects of various therapeutic approaches. A multidisciplinary approach

involving psychology, education, and reproductive health will be essential in providing better support for children with Turner Syndrome.

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