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Article

Brazilian Twin Studies: A Scoping Review

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Abstract

The current study was motivated by an interest in deepening understanding of Brazilian twin research, which is underrepresented internationally, in an effort to rectify this situation. Our aim was threefold: (1) to carry out a comprehensive investigation of Brazilian research on twins according to the area of knowledge; (2) to evaluate the representation of research in the field of psychology in comparison with other areas; (3) to evaluate characteristics of the research that may have contributed to its exclusion from the comprehensive meta-analysis of 50 years of twin research. A scoping review was performed according to PRISMA guidelines. Titles and abstracts were searched up to 2022 in six databases: CAPES, BDLTD, PePSIC, PubMed, Google Scholar, and SciELO, using selected keywords both in Portuguese and in English (e.g., 'twins' and 'Brazil'; 'twinning' and 'Brazil'; 'gemelaridade' [twinning], and 'gêmeos' [twins]). Three hundred and forty publications were included in the review. Approximately half (53.8‰) used the classic twin design to investigate the heritability of several traits, and the other half (46.2%) used other research designs. The scoping review showed that the number of publications doubled approximately every 10 years. Most publications were from the health area, with medicine accounting for approximately half of the studies, followed by psychology, odontology, and biology. We found that the interest in studying twins among Brazilian scientists is increasing over the years and there are reasons to be enthusiastic about the potential impact of this trend in the global scenario.

Keywords: Twin; Heritability; Behavior Genetics; Scoping review

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In the classical twin design heritability is estimated by comparing the similarity of monozygotic (MZ) twins, who are genetically identical, and dizygotic (DZ) twins, who share 50% of their genes, on average. Heritability, a statistical concept expressed by h^2 and ranging from zero to one, indicates what proportion of the population variability in a trait is due to genetic differences among people. It gives an initial indication of the relative importance of genes (nature) and environment (nurture) on complex traits, which serves as a reference for future gene-mapping efforts (Austerberry et al., 2022; MedlinePlus, 2020).

A landmark meta-analysis of the heritability of human traits was conducted by Polderman et al. (2015), based on half a century of twin studies published between 1958 and 2012, finding an overall heritability index of 0.49. The 10 top investigated traits, accounting for 59% of all those investigated, were temperament and personality functions, weight maintenance functions, general metabolic functions, depressive episode, higher level cognitive functions, conduct disorders, mental and behavioral disorders due to use of alcohol, anxiety disorders, height, and mental and behavioral disorders due to use of tobacco. This meta-analysis of Polderman et al. (2015) examined 2748 publications with twin samples coming from 39 different countries. It is notable that 82% of all studies were conducted with twin participants from seven countries: United States, United Kingdom, Australia, Netherlands, Sweden, Denmark and Finland. The continents of South America (0.5%), Africa (0.2%) and Asia (5%) were clearly underrepresented.

The overrepresentation of WEIRD (Western, Educated, Industrialized, Rich and Democratic) populations in twin studies can compromise the generalizability of findings (external validity). Heritability is a statistical index defined in relation to a given population and a given environment. Uchiyama et al. (2022) observe that heritability scores are greatest when the pertinent environmental input is homogeneous across a sample, and become smaller when the environmental input is more diverse. In a review article, in which they discuss how to maximize the value of twin studies in health and behavior, Hagenbeek et al. (2022) concluded that stronger efforts to increase representativeness of the general population and of global diversity are needed. It is urgent to consider non-WEIRD populations that can contribute to a more comprehensive Science.

At our request, the author who coordinated the meta-analysis (Polderman et al., 2015) sent us the list of Brazilian studies, showing that they had been carried out in the fields of genetics (Callegari Jacques et al., 1977, Rapaport et al., 1991), medicine (Custodio et al., 2007), odontology (Bretz, Corby, Hart et al., 2005; Bretz. Corby, Schork et al., 2005; Bretz et al., 2006; Bretz et al., 2011; Su et al., 2008), and physical education (Machado et al., 2010; Reis et al., 2007). No Brazilian research in the field of psychology was included. This lack of Brazilian twin studies on behavior and psychological processes is remarkable, especially considering that among the most studied issues internationally were subjects related

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to temperament and personality, behavioral problems, and cognition. Only 10 studies had been conducted with Brazilian twins. This underrepresentation of twin studies is notable, considering that Brazil is the world's fifth-largest country by area and the seventh most populous. Half of the Brazilian studies had been carried out under the coordination of professors from universities located in Brazil and half under the coordination of a Brazilian professor who emigrated to the United States (New York University; with all data collection carried out in the city of Montes Claros, Minas Gerais, Brazil).

The meta-analysis conducted by Polderman et al. (2015) focused on classic twin studies. In addition to the classic twin studies, there are other twin study designs for individual differences research. Segal (1990) distinguished 10 designs that have been used in twin research (Table 1): Classic Twin Study with MZ and DZ twins Reared Together; Cotwin Control Studies; Singleton Twins; DZ Twin Designs; Longitudinal Twin Studies; Twin-Family Design; Twins as Couples; Twins and Nontwins; Partially Reared Apart Twins; and Twins Reared Apart. Segal et al. (2003) organized the extant research in the psychological literature on twins into four theoretical perspectives: behavioral-genetic, social-genetic, evolutionary psychological/human ethology, and psychoanalytic/psychodynamic.

The International Society for Twin Studies (ISTS) periodically updates information on twin registries around the world, publishing the findings in the journal *Twin Research and Human Genetics* (Hur et al., 2019; Hur & Craig, 2013). According to the latest update, the Painel USP de Gêmeos (USP Twin Panel) was the only group to represent Brazil (Otta et al., 2019) in a total of 61 articles on twin registries from 25 countries. The organizers of the compilation noted that in South America, a continent that had produced little twin research, there were only three new active registries, the University of São Paulo Twin Panel (Painel USP de Gêmeos) in Brazil, created formally in 2017, and two registries in Mexico, created in 2018 and 2019 respectively.

The main goal of the Painel USP de Gêmeos is to foster research on behavior and health using the classic twin method and variations of this method described by Segal (1990). Investigating twinning rates in the entire country of Brazil between the years 2002 and 2013, based on DATASUS, an official public governmental database, we obtained a total of 35,051,790 maternities between 2002 and 2013 and 329,006 twinning maternities (Varella et al., 2018). Considering the whole country, the overall average rate of twins was 9.39‰, with a 14.54% increase in the twinning rates from 8.80‰ in 2002 to 10.08‰ in 2013. Among the five major regions of Brazil, we found a small but significant variation in twinning rates. More developed regions (Southeast: 10.34‰ and South: 10.06‰) presented higher twinning birth rates than developing ones (Northeast: 8.68‰ and North: 7.32‰), with the Central-West in an intermediate position (9.05‰). Several factors may interact to produce this result. Women with higher socioeconomic status tend to pursue more extended periods of study, delaying reproduction and increasing the likelihood of having offspring at an older age, subsequently elevating the chance of multiple pregnancies. Additionally, individuals with higher socioeconomic status generally maintain a richer and more diverse nutritional diet, contributing to a higher likelihood of multiple pregnancies.

According to the 2015 Report of the National Embryo Production System (SisEmbrio, 2015), there were 106 assisted reproduction centers in the country. More centers were located in the more developed regions with higher twinning rates (Southeast: 56.60% and South: 23.60%) than in the developing ones with lower twinning rates (Northeast: 11.32% and North: 0.94%). São Paulo, being the wealthiest state and having the largest population in Brazil, reported the highest average twinning rate in the Southeast (Otta et al., 2016: 11.96‰; Cardoso-dos-Santos et al., 2018: 10.69‰) and housed the greatest number of assisted reproduction centers (37 out of the total 106, with a significant difference from Paraná, the second state with the greatest number of centers, registering 13). The private sector of medicine is the primary provider of ART. Women of higher socioeconomic status can afford ART, thereby increasing the probability of multiple pregnancies.

Colletto et al. (2003) compared the rates of multiple births in four hospitals of different socioeconomic levels over a decade. The hospital with the lower socioeconomic level presented multiple birth rates of approximately 8‰, considered as the natural rate. The other three hospitals exhibited increased rates positively correlated with socioeconomic level. The DZ twinning rate rose with socioeconomic levels, ranging from 4.3‰ at hospital 1 to 14.4‰ at hospital 4 (i.e., a rate three times higher). The MZ rate also increased, though less significantly, from 3.3‰ to approximately 7.0‰.

Future studies should aim to untangle the complex web of influential factors by examining and integrating indicators such as nutrition, education, socioeconomic status, and assisted reproduction. Studies conducted in traditional societies with natural reproduction, such as in Gambia (Sear et al., 2001), show increasing twinning rates as a function of maternal age. In Nigeria, a contrasting association was observed between twinning rates and social class compared to Brazilian results (Nylander, 1979). Within

Table 1. Ten designs that have been used in twin research (Segal, 1990)

Twin research designs	
1. Classic Twin Study: MZ and DZ Twins Reared Together	MZ twin pairs resemblance is compared with DZ twin pairs resemblance
2. Cotwin Control Studies	Different treatments are provided to each member of a MZ twin pair
3. Singleton Twins	Studies conducted with a member of a twin pair whose co-twin died at or shortly after birth
4. Dizygotic Twin Designs	Studies conducted with DZ twins, comparing for example same-sex and opposite-sex pairs
5. Longitudinal Twin Studies	Trait consistency over a specific time period in the life course
6. The Twin-Family Design	In addition to cotwin comparisons, trait similarity between spouses, siblings, and 'half-siblings' is examined
7. Twins as Couples	Twins are studied both alone and together, under standard conditions
8. Twins and Nontwins	Investigators study the singleton siblings of twins, sibling pairs who are close in age, or pairs of unrelated, age-matched singleton
9. Partially Reared Apart Twins	Comparison of twins who have lived apart for a number of years with twins who have always lived together
10. Twins Reared Apart	Study of twins separated early in infancy and raised in uncorrelated trait relevant environments

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the lower social class (62‰), the twinning rate exceeded that of the upper class (15‰), showing notably elevated values in comparison to known data. Social class primarily influenced the DZ twinning rate, while the MZ twinning rate (4‰) remained relatively constant. A key environmental (dietary) explanation was proposed, suggesting that women in the lowest social class predominantly consume the local or 'native' diet, which includes yams containing estrogen-like substances. In contrast, women in the highest social class adhere to a more 'European diet'.

Twinning rates in Brazil are increasing, as well as the demand for information about this population (Cardoso-dos-Santos et al., 2018; Otta et al., 2016; Varella et al., 2018). Furthermore, there are relatively few twin studies in non-WEIRD populations, and Brazil has a huge potential for twin studies, considering its vast culturally, ethnically and economically diverse non-WEIRD population (Bosi, 1992; Instituto Brasileiro de Geografia e Estatística [IBGE], 2011, 2017).

Current Study

The current study was motivated by an interest in deepening understanding of Brazilian twin research, which is underrepresented internationally, in an effort to rectify this situation. The objectives were: (1) to carry out a comprehensive investigation of Brazilian research on twins according to the area of knowledge; (2) to evaluate the representation of research in the area of psychology in comparison with other areas; (3) to evaluate characteristics of the research that may have contributed to its exclusion from the comprehensive meta-analysis of 50 years of twin research. In order to evaluate the state of research on twins in Brazil and helping to identify knowledge gaps, a scoping review was conducted. Scoping reviews are useful to determine the scope of a body of literature on a particular topic and field, indicating the volume of evidence, as well as giving an overview of the area (Munn et al., 2018).

Materials and Methods

This scoping review was performed according to PRISMA 2020 guidelines (Page et al., 2021).

Search Strategy

An electronic literature search, with date restriction up to 2022 (no start date restriction), was conducted in six relevant databases: CAPES (Journal Portal of the Brazilian Coordination for the Improvement of Higher Education Personnel), BDLTD (the Brazilian Digital Library of Theses and Dissertations), PePSIC (Electronic Psychology Journals), PubMed (Biomedical Literature from Medline), Google Scholar (broad search for scholarly literature), and SciELO (Scientific Electronic Library Online). An initial search was conducted using the words 'twins' and 'Brazil', 'twinning' and 'Brazil' (both in Portuguese and in English), 'gemelaridade' (*twinning*), and 'gêmeos' (*twins*) as descriptors in the title. As inclusion criteria, the publications were to be available in pdf and be written in Portuguese and/or English. Only studies focusing on twins and studies with twins as methodology were included: (a) *studies focusing on twins*, that aimed to understand some twin issue (e.g., Twinning rate in a Southeastern Brazilian population); (b) *studies with twins as methodology*, using twin research designs to better investigate a given trait or health condition (e.g., heritability of aerobic power of individuals in Northeast Brazil). Studies mentioning twins as part of the study sample, but without focusing on twins, were excluded. Abstracts and full-text articles that met inclusion criteria were retrieved and reviewed by two researchers.

To map the state-of-the-art of Brazilian twin research, the following categories were used to analyze the database: 1. *Regions of the country* (South, Southeast, Central-West, Northeast and North); 2. *Type of institution* (Public, Private); 3. *Publication year* (<2000, 2001−2009; 2010−2019; 2020−2022); 4. *Type of publication* (journal article, book or book chapter, conference abstract, PhD dissertation, master's dissertation, undergraduate dissertation); 5. *Type of study* (experimental, observational), 6. *Study design* (cross-sectional, longitudinal); 7. *Areas of study* (e.g., psychology, biology, medicine); 8. *Subarea* (genetics, medical clinic); 9. *Number of twin pairs*; 10. *Participants* (twins, parents of twins, twins and parents), 11. *Participants' age group* (childhood, adolescence, adult); 12. *Zygosity* (MZ, DZ, both); 13. *Twin's gender* (male, female, both); 14. *Method for zygosity classification* (e.g., PCR, questionnaire); and 15. *Case study* (yes, no). Areas of study and subareas were classified according to Table of Knowledge Areas of the Brazilian National Council for Scientific and Technological Development (CNPq).

Specific additional categories were applied to classify the studies carried out in the field of psychology: 1. *Psychology subareas* (e.g. psychobiology/ethology, clinical psychology); 2. *Research methods* (quantitative, qualitative, theoretical); 3. *Empirical study methods* (direct observation; scales, questionnaires, inventories, interviews; experiments comparing control versus experimental groups; case studies).

To investigate what topics twins' research in psychology has focused on, we extracted keywords from publications. Through the MeSH database (https://www.ncbi.nlm.nih.gov/mesh/), we standardized the terms, obtaining thematic categories. The MeSH (Medical Subject Headings) thesaurus is a controlled vocabulary of the National Library of Medicine (NLM), which indexes citations from PubMed.

Results

Overview of Twin Studies Conducted in Brazil

An initial search identified 2496 publications. After removing duplicates ($n = 629$) and applying an initial application of the inclusion criteria ($n = 1472$), a sample of 395 publications was selected. Most of our sample was composed of studies with twins as methodology ($n = 183$), followed by studies focusing on twins ($n = 157$). Studies mentioning twins as part of the study sample, but without focusing on twins, were excluded ($n = 55$). Our final sample was composed of 340 studies (Figure 1).

Although twin studies have been conducted in the five geographical regions of the country, a large proportion was from Southeast (57.9%) and South (23.5%), while Northeast (13.8%), Central-West (2.9%), and North (1.8%) were heavily underrepresented. The majority of these studies received public funding, having been conducted exclusively in public institutions (82.4%).

Figure 2 shows the number of studies published per year. The increase in the number of publications over time is notable: 11.2% of the studies were published before 2000, 24.4% between 2000 to 2009, 49.1% between 2010 to 2019, and 15.3% between 2020 to 2022.

The most common type of publication consisted of papers (60.9%), followed by dissertations (25%), theses (10.9%), completed undergraduate coursework (1.8%), abstracts presented at

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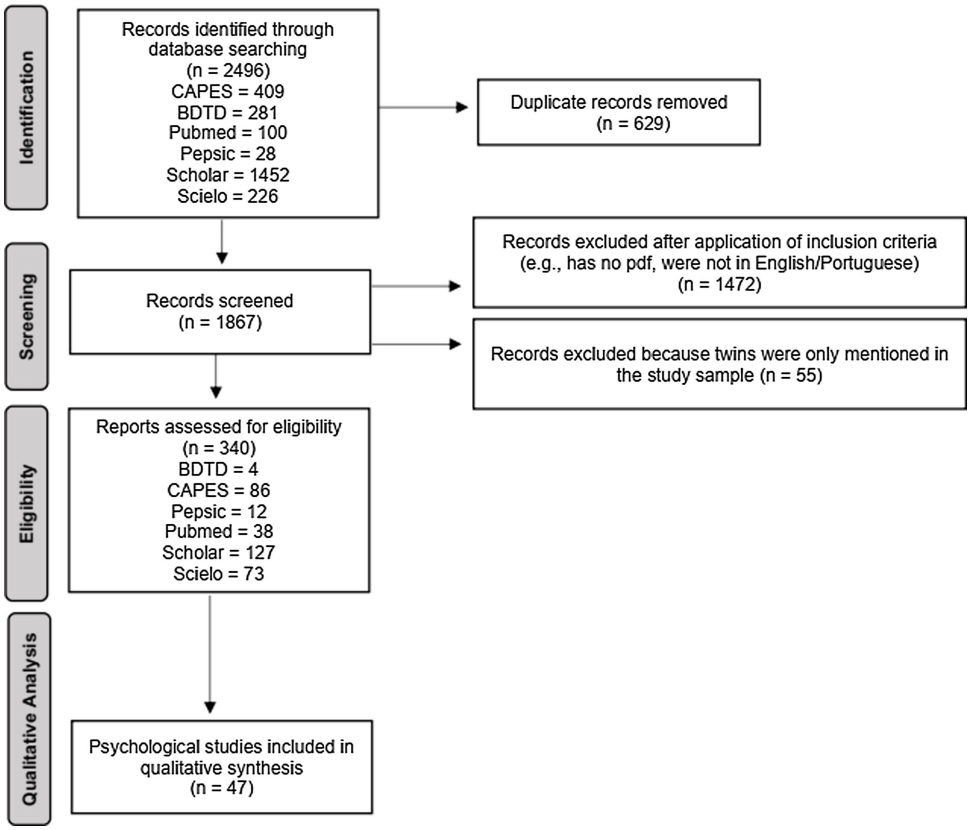

Figure 1. Flow of articles through the phases of the scoping review (http://www.prisma-statement.org/PRISMAStatement/FlowDiagram).

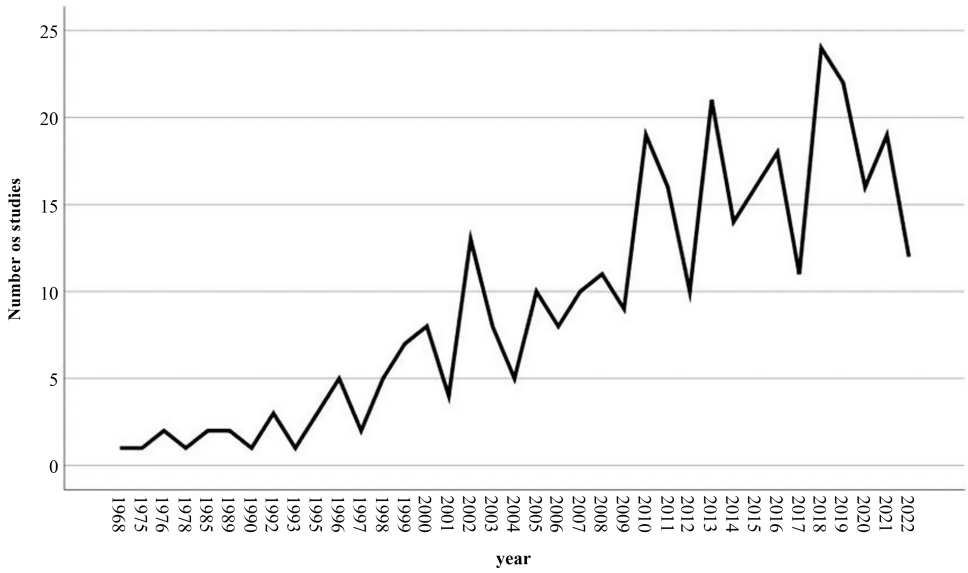

Figure 2. Frequency of twin studies per year of publication.

conferences (0.9%) and book chapters (0.6%). Half the studies were observational, 30% were case studies, 15% experimental and 5% theoretical.

The majority of studies used a cross-sectional design (88.2%). Regarding areas of study, medicine was responsible for almost half of the studies, being followed by psychology (14.4%), odontology (10.6%), and biology (8.5%) (Table 2). It is notable that most of the case studies were from the medical field (60%).

Most of the studies investigated twin children (42.5%), followed by twin children and parents (18.9%), adult twins (9.8%), and twins' parents (9.5%). We noted that among these studies, 21.2% focused on the pregnancy. Of the studies that investigated twins, 39.5% focused only on MZ pairs, 21.9% on MZ and DZ pairs, and 7.4% only on DZ pairs. Surprisingly, 38.2% of the studies did not report the number of MZ and DZ twins and in the vast majority of the studies the zygosity classification was unclear (80%). Among the studies that referenced zygosity, the three most used methods were genetic criteria (e.g., C reactive protein or CRP), questionnaires (twins, parents, school reports), and Weinberg estimation.

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Table 2. Frequency of twin studies as a function of areas of study

Area of study	*N*	%
Medicine	161	47.4%
Psychology	49	14.4%
Odontology	36	10.6%
Biology	29	8.5%
Physical education	18	5.3%
Languages	13	3.8%
Education	8	2.4%
Speech therapy	6	1.8%
Physiotherapy	4	1.2%
Sociology	3	0.9%
Mathematics	2	0.6%
Nutrition	2	0.6%
Nursing	2	0.6%
Linguistics	1	0.3%
Economy	1	0.3%
Music	1	0.3%
Occupational therapy	1	0.3%
Pharmacy	1	0.3%
Law	1	0.3%
Motor skills	1	0.3%
Total	**340**	**100**

Brazilian Twin Research in Psychology

Psychology provided 47 out of 340 publications selected in this review. Similar to general Brazilian twin research, there has been an increase in the production of twin studies in the field of psychology over the years (Figure 3); 4.3% have been published before 2000, 21.3% between 2000 to 2009, 55.3% between the years 2010 to 2019, and 19.1% between 2020 to 2022.

Most of the studies were articles (46.8%) and dissertations (40.4%) that received public funding (74.5%) and were conducted in the Southeast (48.9%) of the country. The most represented subareas in psychology were developmental psychology followed by psychobiology/ethology (Table 3).

Regarding research methods, 76.6% of studies were cross-sectionally designed. In addition, 55.3% were qualitative, 25.5% quantitative, 6.4% quantitative and qualitative, 8.5% theoretical, and 4.3% were reviews. Among the qualitative-quantitative research, 36.6% were case studies, followed by studies that evaluated twins' psychological characteristics through self or other-report instruments (36.6%) and interview (17.1%). Behavioral observation represented 9.8% of the studies.

Concerning the target-public, approximately half of the studies evaluated exclusively twins (44.6%), 55% of the participants were children, 30% were adults and 15% were adolescents. During childhood, half of the studies focused on mothers' reports. We noticed an interest in the comprehension of the experience of twins' parents and parent-child interaction since parents-twin dyads (21.3%) and parent behaviors (19.1%) were analyzed.

Of the studies that gave details about zygosity, different from other areas that focused only on MZ twins, the majority of the psychological studies selected MZ and DZ twins (54.5%), followed by studies composed only of MZ (31.8%) or DZ (4.5%) twins. Most studies did not provide information about the zygosity diagnosis method (73.6%). When informed, zygosity was diagnosed mainly through questionnaires (18.4%; e.g., Christiansen et al., 2003). Regarding sex, 53% of studies recruited individuals of both sexes.

Regarding topics of twins' research in psychology based on keywords (Table 4), the most frequent broad category was 'Behavior and behavior mechanisms' (44.6%), followed by 'Behavioral disciplines and activities' (14.3%), 'Psychological phenomena' (9.8%), 'Persons' (8.0%), 'Analytical, diagnostic and therapeutic techniques and equipment' (6.3%) and 'Anthropology, education, sociology and social phenomena' (6.3%).

Discussion

The present study, the first known scoping review of Brazilian twin studies, showed researchers' interest in investigating the subject of twinning in the national scientific domain. Based on the 340 studies surveyed through online databases from 1968 to 2022, we found that approximately half (53.8%) used the classic twin design to investigate the heritability of several traits. Only 10 of those studies conducted between 1958 and 2012 met the criteria for inclusion in the landmark meta-analysis on heritability based on half a century of twin studies (Polderman et al., 2015); this justifies concern for methodological improvement to maximize the value of the investigation conducted. However, it is notable that other research designs (Segal, 1990; Segal et al., 2003; Segal et al., 2020) have been used in approximately half of the twin studies reviewed in the current review (46.2%). For example, perinatal outcomes in twin pregnancies delivered in a Brazilian university hospital were investigated focusing on chorionicity as the main predictive factor (Assunção et al., 2010). Such types of investigations were not included in the meta-analysis.

Our review has revealed expansion of the volume of twin research over the years. The number of publications doubled approximately every 10 years. Even in the last 2 years (2020 to 2022), the amount of studies represented 15% of the total number of publications. This increase indicates the interest of Brazilian scientists in twin research. There is also evidence that twinning rates in Brazil are increasing (Cardoso-dos-Santos et al., 2018; Otta et al., 2016; Varella et al., 2018), creating demand for information about this population, especially considering the higher risk for pregnancy complications and perinatal morbidity and mortality in comparison with singleton pregnancies.

In the current review, we located published research conducted in the five regions of the country. Most research was funded by government grants and was performed in public universities, concentrated in the Southeast and South regions, while the Northeast, Central-West, and North regions were heavily under-represented. Twinning rates were also higher in the Southeast and South than in the other regions (Varella et al., 2018). The existing bias in the regional distribution of research should be corrected. Brazil is a culturally and socio-economically diverse country and it is important that all regions are represented. The USP Twin Panel located at Southeast of Brazil is actively seeking to expand twin enrollment nationwide, and to build a researchers' network that extends the contributions of the twin studies from a psychobiological perspective to the international community. The Executive Committee was expanded beyond the University of São Paulo to include professors from three other institutions: Universidade Federal Rio Grande do Norte (UFRN), Universidade Federal da

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Table 3. Frequency of twin studies as a function of psychology subarea

Subareas	*N*	%
Developmental psychology	14	29.8%
Psychobiology/Ethology	11	23.4%
Clinical psychology	7	14.9%
Psychoanalysis	6	12.8%
Psychology and health	2	4.3%
Behavior analysis	2	4.3%
Educational psychology	2	4.3%
Social psychology	2	4.3%
General/Transversal	1	2.1%
Total	**47**	**100%**

Bahia (UFBA), and Universidade Federal do Espírito Santo (UFES), aiming to define and implement strategies to engage our target population (Luchesi et al., 2023; Monticelli et al., 2023).

In the current review, upon examining the age distribution, we found that some age groups were more represented than others in the samples of research participants. Children and adults were more represented relative to adolescents, and the elderly were underrepresented. A fifth of the studies focused on pregnancy. The high risk involved in twin pregnancies and deliveries make this an important public health topic (Pison & d'Addato, 2006).

With regard to zygosity, we found that MZ twins were more represented than dizygotic twins among the research participants. This is a common finding in twin studies: two of every three volunteer pairs are MZ in volunteer twin samples (Lykken et al., 1978; Lykken et al., 1987). Differences in intrinsic motivation seem to explain this finding — MZ twins are more interested in participating in research than DZ twins. This bias should be overcome to maximize the value of studies in health and behavior. 'The only adequate solution to this problem may be to provide sufficient extrinsic incentive . . . to overcome the strong recruitment bias documented' (Lykken et al., 1978, p. 1).

In our review, most of the studies were observational and had a cross-sectional design. Zygosity assessment also deserves attention. We found that 80.2% of the studies did not inform which zygosity determination method was used, explaining why they were not included in the landmark meta-analysis of 50 years of twin studies (Polderman et al., 2015). Most of the publications that mentioned the method used referred to DNA, the golden standard for zygosity determination, and participants' opinion, the latter of which does not have a high accuracy rate (Varella et al., in press). Wrong assumptions give rise to misclassification of twins even among healthcare professionals, influencing zygosity perception of twins and their families and biasing heritability estimates in twin studies. For example, the wrong assumption that all dichorionic twins are DZ can lead to one third of MZ twins being incorrectly categorized as DZ (Umstad et al., 2019). Fused placentas in dichorionic fetuses can be mistaken for a single placenta and give rise to misclassification of DZ twins as MZ. DNA, again, is the golden standard for zygosity determination, but there are inexpensive, fast and accessible alternatives. Our group is part of a research team responsible for the Brazilian validation of two zygosity questionnaires comparing the precision of the results with zygosity DNA testing (Varella et al., in press). As far as we know it is the first Brazilian study to perform this type of validation. We found that the Brazilian Portuguese version of the Danish Zygosity Questionnaire created by Christiansen's et al. (2003), with only four self-report questions based on similarity in appearance and difficulties that people had telling them apart, has a 96.7% accuracy when compared with DNA testing.

In the present review, most publications were from the health area, with medicine accounting for approximately half of the studies, followed by psychology, odontology, and biology. There was a high proportion of case studies with twins in the medical field in which rare conditions and medically complex situations were examined (e.g., Santos et al., 2017). In the meta-analysis of 50 years of twin studies (Polderman et al., 2015) most of the publications were also from the field of medicine. It is notable that of only 10 Brazilian studies included in this meta-analysis, none were from the field of psychology, while most studies conducted with WEIRD samples investigated psychological themes. In this review, we found 47 Brazilian twin psychological studies.

In our review, we found that studies with twins are increasing over time in the field of psychology, having almost quintupled in

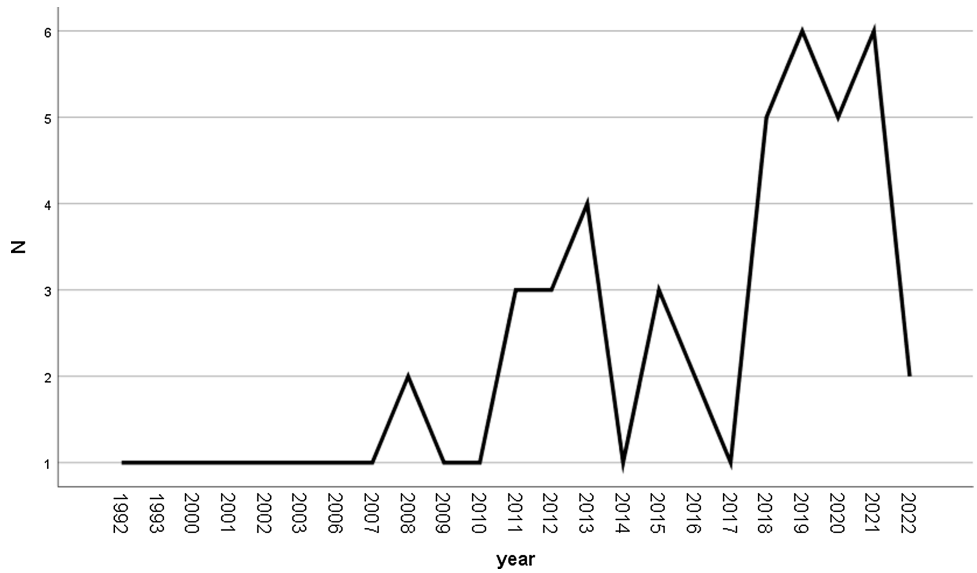

Figure 3. Frequencies of twin studies in psychology per year of publication

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Table 4. Frequency of topics of twins' research in psychology based on keywords

Behavior and behavior mechanisms (44.6%)					
Psychology, social (48.0%)			**Personality (30.0%)**	**Behavior (16.0%)**	**Adaptation, psychological (2.0%)**
Family relations (54.2%) Sibling relations (53.8%) Mother-child Relations (23.1%) Parent-child relation (23.1%)	Family (41.7%) Family (20.0%) Maternal behavior (20.0%) Family characteristics (10.0%) Family relations (10.0%) Maternal-fetal relations (10.0%) Parenting (10.0%) Parents (10.0%) Single parent (10.0%)	Interpersonal relations (4.2%)	Personality (80.0%) Intelligence (13.3%) Gender (6.7%)	Communication (37.5%) Behavior (12.5%) Behavioral symptoms (12.5%) Child behavior (12.5%) Personal satisfaction (12.5%) Sexual behavior (12.5%)	Attitude (2.0%) Child rearing (2.0%)
Behavioral disciplines and activities (14.3%)					
Behavioral sciences (50.0%)		**Psychotherapy (31.25%)**		**Human development (12.5%)**	
Psychoanalysis (37.5%) Ethnopsychology (25.0%) Behavioral research (12.5%) Evolutionary psychology (12.5%) Neuropsychology (12.5%)		Child development (100.0%)		Family therapy (40.0%) Psychotherapy (40.0%) Behavior therapy (20.0%)	
Psychological phenomena (9.8%)					
Psychoanalytic theory (63.6%)			**Psychophysiology (27.3%)**	**Mental processes (9.1%)**	
Object attachment (57.1%) Narcissism (14.3%) Oedipus complex (14.3%) Superego (14.3%)			Functional laterality (66.7%) Sleep (33.3%)	Perception (100.0%)	
Persons (8.0%)					
Infant (37.5%) Child (25.0%) Mother (25.0%) Housed persons (12.5%)					
Analytical, diagnostic and therapeutic techniques and equipment (6.3%)					
Investigative techniques (57.1%)		**Diagnosis (28.6%)**		**Evaluation studies as topic (14.3%)**	
Genetic association studies (75.0%) Interviews (25.0%)				Validation studies as topic (100.0%)	
Anthropology, education, sociology and social phenomena (6.3%)					
Education (57.1%)		**Social Sciences (42.9%)**			
Education (50.0%) Schools (50.0%)		Sociological factors (66.7%)		Culture (33.3%)	
		Adoption 50.0%) Socialization (50.0%) Culture (33.3%)			
Health care (2.7%)					
Health facilities (33.3%)		**Health services (33.3%)**		**Quality of health care (33.3%)**	
Hospitals (100.0%)		Maternal health services (100.0%)		Epidemiologic factors (100.0%)	
Mental disorders (2.7%)					
Autism spectrum disorder (100.0%)					
Reproductive physiological phenomena (2.7%)					
Reproduction (66.6%) Puerperium 33.3%)					
Etiology (0.9%)					
Transmission (100.0%)					

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Phenomena and processes category (0.9%)
Genetic phenomena (100.0%)
Inheritance patterns (100.0%)
Information science (0.9%)
Review literature as topic (100.0%)

the period between 2000 and 2019 compared to the period before 2000, and almost tripled between 2010 and 2019. In recent years (2020 to 2022), these studies represent almost one fifth of total publications. In our opinion, a better understanding of relations between 'nature' and 'nurture' in human development and moving beyond the dichotomy (e.g., Bussab & Ribeiro, 1998; Ribeiro et al., 2004; Singh, 2012) underlies this increased interest in twin studies by Brazilian psychologists. The most represented subareas were developmental psychology followed by psychobiology. The creation of the USP Twin Panel, a registry of twins and their parents focused on psychological and behavioral studies, contributed to the increase in studies over the last eight years, especially in the area of psychobiology and ethology (Otta et al, 2019).

Half of the twin studies of children collected parent reports. They assessed twins through mothers' reports, aiming to understand the experiences of parenting twins and the interactions between parents and children. Our review shows the need for more twin studies with fathers' participation. The developmental cycle should be more widely represented, beyond adolescents and adults. Older adults' participation should be encouraged in research with twins from a psychological perspective.

Different from the general pattern of Brazilian twin research, which shows a skewed distribution towards MZ twins, studies reviewed in the psychology field had a more balanced sample distribution with respect to zygosity. Comparing the profile of self-registered adult twins with the profile of children registered by their parents, based on the members of a Brazilian twin registry, a clear difference was found: predominance of MZ over DZ among adults and a balanced ratio among children (Otta et al., 2019). In other words, when the decision to participate in a research study is made by the parents, the bias disappears.

Half of the studies were qualitative, followed by a quarter of quantitative studies. Case studies and the evaluation of measurement instruments were the most frequent among the publications reviewed. This was followed by interviews and behavioral observations. Recruitment issues represented a challenge when conducting research with twins, as they represented a relatively small segment of the population (Yelland et al., 2021). This can be overcome through research networks (https://l1nq.com/gFw7t), the involvement of twin registries such as the USP Twin Panel (Otta et al., 2019) and parents of twins associations such as the *Me Two* (https://metwo.com.br/).

Almost half of the topics in psychological twin research were related to behavior and its mechanisms, focusing on family and family relationships (especially sibling relationships), personality, and communication. The interest in deepening knowledge about personality and relationships is notable. Also noteworthy is the interest in studying attachment as a psychological phenomenon, and in deepening knowledge about the bond of affection between siblings and with their parents. Finally, also present is the interdisciplinary nature of psychological studies with other areas of knowledge, especially studies in education and the social sciences.

Limitations and Prospects

The main limitation of the current review is that the number of publications identified as suitable for inclusion was relatively small, reflecting the state of the art of Brazilian twin research. In comparison to 2748 publications in the Polderman et al. (2015) database, our database included 395 publications. This number was comparable to the number of studies of the UK (e.g., USA: 947; UK: 377; AU: 259). However, it has also be taken into account that Polderman et al. (2015) focused on the classical twin design and in the current review we also include twin studies using other twin methodologies. The corresponding proportions were 53.8% and 46.2%.

Our scoping review explored and described the available evidence on Brazilian twin research, identified knowledge gaps and suggested methodological standardizations to maximize the value of twin studies in health and behavior. Findings presented show that more research is needed and may be used to guide further investigation. The interest in studying twins among Brazilian scientists is increasing and there are reasons to be enthusiastic about the potential impact of this science production on a global scale. There is also growing recognition that maximizing the value of twin studies in health and behavior depends on twin research being conducted around the world including non-WEIRD populations (e.g., Hagenbeek et al., 2022).

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