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Guest Editorial

Twin Registries Worldwide: An Important Resource for Scientific Research

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Twins can provide unique opportunities to study causal influences on variation in human behaviors, development, and diseases. During the past 10 years, the number of twin registries has increased rapidly across the globe and we thought it timely to bring these to the attention of our readership. In this special issue, we invited papers on twin registries and cohorts from 28 countries representing five continents. Subjects covered include how to establish and maintain twin registries, accurately assess zygosity, collect biospecimens, and other important issues related to twin studies. This special issue shows that over 1.5 million twins and their families are participating in twin studies worldwide. Research interests will be highlighted, with the aim of fostering collaborative research.

■ **Keywords:** twin registry, epidemiology, zygosity, gene environment interaction, epigenetics, common diseases

Welcome to the special issue of *Twin Research and Human Genetics* on 'Twin Registries Worldwide: An Important Resource for Scientific Research'. The twin method can be traced back to Galton's (1876) assertion that twins can help tease out effects of genes and environment. It is now well recognized in the scientific community that twins are powerful and flexible tools to achieve understanding of the biological substrate of complex human diseases and behaviors. The twin method was traditionally used to estimate heritability, and has now evolved to locate genetic variants that explain heritability, and to study the regulation of gene expression, including epigenetic modifications on the genetic material, cellular processes involving metabolites, the human microbiome, and pharmacogenomics for human variations in response to medications. At the same time, as indicated in this special issue, many twin researchers have also begun to search specific environmental sources of phenotypic variation that interact with genetic factors. Twin pairs discordant for diseases and behaviors and the quantitative genetic method with structural equation modeling techniques are especially useful to detect these environmental sources. The paradigm of twin studies is now being shifted toward understanding of how macro- and micro-environmental factors interplay with complex biological processes.

In 2002, when *Twin Research* published its first special twins cohort issue (Busjahn, 2002), 36 papers were included. As it became apparent that twin research was continuing to expand, another special issue was published in 2006 (Busjahn & Hur, 2006), which included 53 papers. In the current issue we are able to collect 71 papers in total. Therefore, this would indicate that the number of twin research cohorts has almost doubled during the past 10 years (Figure 1). The number of countries involved in twin research has also increased; the 2002 issue presented data from 16 countries, which increased to 20 in 2006, and in this issue it has increased to 28 countries (Figure 2). These figures assure us that twin research is a fast-growing field of science across the globe. Traditionally, it has been suggested that twin studies limit their conclusions to explanation of variation within a population (Plomin et al., 2001). However, as many twin registries in this issue are either multinational or are inviting international collaborations, twin analyses are starting to move beyond within-population analyses (Figure 2 and

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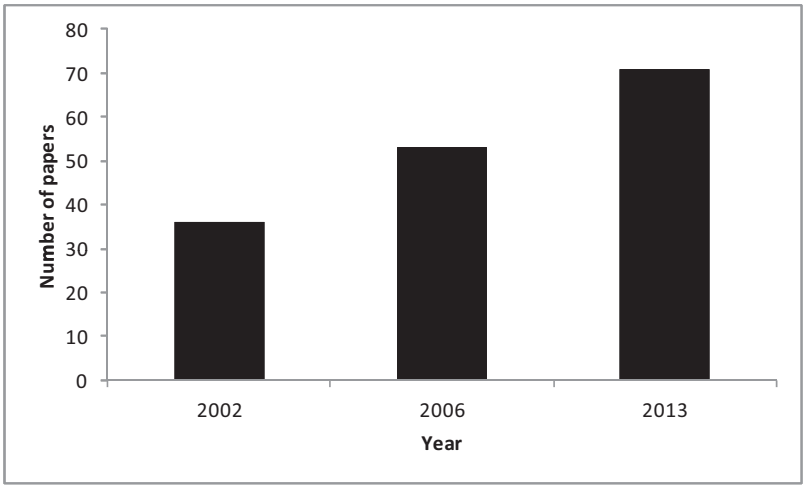

FIGURE 1

Number of papers in the three special issues on twin registers in the world published in *Twin Research* (2002) and *Twin Research and Human Genetics* (2006 and 2013).

Table 1). This special issue is a comprehensive coverage of currently active twin cohorts around the world. While many of the papers in this issue have updated their previous articles published in the 2002 and/or 2006 special issues, describing the progress they have made, new twin registries that have emerged during recent years have also been included in this issue.

New Twin Registries

The Cuban Twin Registry is a nationwide, population-based registry consisting of approximately 58,000 pairs of twins who were identified through the National Citizen Identity Registry. This twin registry is almost free of ascertainment bias as it includes over 99.9% of all twins available from the total population in Cuba. Undoubtedly, this registry is a powerful resource to study genetic and environmental etiologies of complex diseases in the Cuban population. The successful construction of the registry appears largely due to the efforts of door-to-door visits and in-person interviews that the investigators made, as well as the support of the Cuban government.

A nationwide, representative school-aged twin registry is currently being developed in the Russian Federation and the Kyrgyz Republic. Utilizing 50,000 school rosters across the country, the investigators are forming a registry of over 100,000 twins aged 7 to 18 years with a general aim to resolve the issues of gene–environment interactions for the development of school achievement and related traits. The investigators also seek international collaborations to use this huge resource to study cross-cultural comparisons on education-related traits.

New registries in two African countries, Guinea-Bissau and Nigeria, are also notable. Although both registries aim to study children and adolescent twins, the ascertainment schemes of the two registries are different. Whereas the Guinea-Bissau Twin Registry collects twin data mainly from hospitals, focusing on diseases and related traits, the Nigerian Twin and Sibling Registry recruits twins largely from schools, and its primarily interests are psychological and mental health variables. As Africans are known to have the highest twin birth rate in the world (Bulmer, 1970), these two registers are likely to increase their sample size rapidly, which will provide new opportunities to study complex human behaviors and disease traits of Africans living in extremely deprived environments.

This issue also presents a brief history and initial findings of the Hungarian, Portugese, and Turkish twin registries in Europe. Although these three registries started with small regional samples and meager financial resources, they are being extended to the whole country. In Asia, nationwide twin registries are being established in Malaysia, Mongolia, and Thailand. The progress and research interests of these three registries are also briefly described in this issue.

We have also included many new twin registries from the United States. For example, the Arizona Twin Registry, which was developed from 600 young twins ascertained from birth records in the state of Arizona, offers a new resource to explore interesting questions of how early competency and resilience develop and moderate genetic and environmental risk factors for childhood physical and mental health problems. The Boston University Twin Project (BUTP) is also a new longitudinal study of young twins recruited from birth records of the state of Massachusetts. The target phenotypes of the BUTP are childhood temperament and behavior problems, with specific focus on activity level. The unique feature of the BUTP is the use of multiple mechanical measures to assess phenotypes across multiple contexts. These measurement strategies are important because they can help increase generality of the findings, as

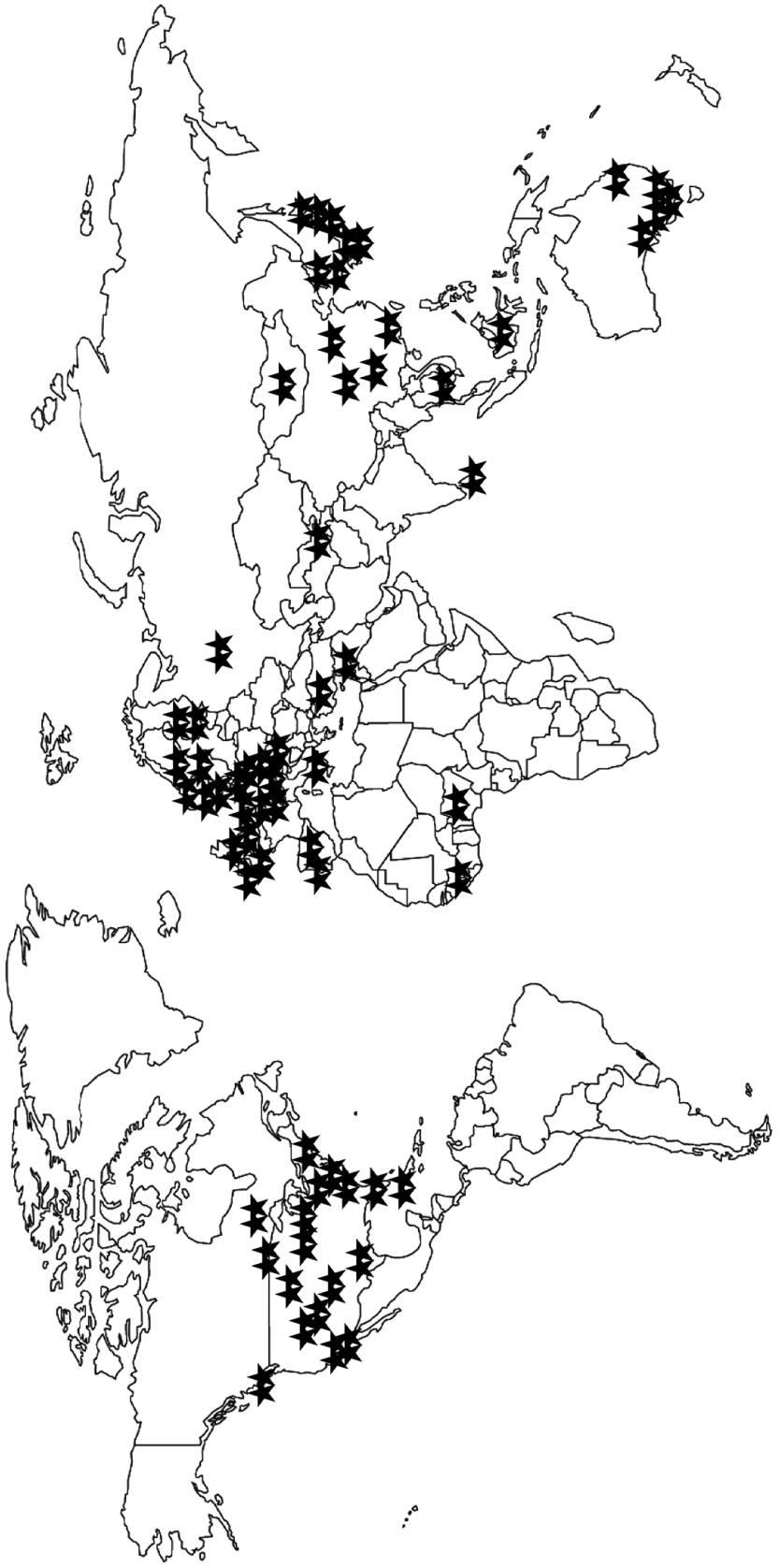

FIGURE 2
Location of twin studies featured in this issue. Each study is shown as a double star.

TABLE 1

An Overview of Twin Registries Worldwide

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
Australia	Australian Twin Registry (ATR)	John Hopper et al.	National	40,000 twin pairs	All ages	Yes	Media, Australian Multiple Birth Association (AMBA), hospitals	Multiple aspects of health, disease, risk factors, behavior and lifestyle	DNA, Q	Yes
Australia	Teeth and Faces of Twins	Toby Hughes et al. (Grant Townsend)	National	1,293 twin pairs and 2,258 family members	All ages	Yes	ATR, AMBA, newspapers, hospitals, and prenatal exercise classes	Dental development and oral health	DNA	Yes
Australia	Australian Twins and Ophthalmic Traits	Maria Schache and Paul Baird (Maria Schache)	National	1,563 twin pairs	5 years to adults	No	ATR, previous studies, media, word-of-mouth	Eye diseases, ophthalmic traits	DNA, Q	Yes
Australia	The Brisbane Longitudinal Twin Study	Nathan Gillespie et al.	Brisbane	3,408 twins and their 1,572 siblings	12–21 years	Yes	Media, word of mouth	Substance (Cannabis) use, mood, anxiety, psychosis	DNA, Q	Yes
Australia	The Peri/postnatal Epigenetic Twins Study (PETS)	Yuk Jing Loke et al. (Jeffrey Craig)	Melbourne	250 twin pairs & their mothers	3–5 years	Yes	Hospitals	Epigenetic associations of pre-, peri-, and postnatal health and related traits	DNA, Chori-onicity	Yes
Belgium	The East Flanders Prospective Twin Survey	Catherine Derom et al.	Province of East Flanders	8,800 twin pairs and 240 triplet sets	0–48 years	Yes	Birth records	Peri- and prenatal conditions, placenta, postnatal health, and behaviors	DNA, chori-onicity, and blood type	Yes
Canada	The University of British Columbia Twin Project	Kerry Jang	Greater Vancouver Area	Approximately 2,000 twin pairs	18–84 years	No	Media	Psychological and psychiatric traits	Q	No
Canada	The Quebec Newborn Twin Study	Michel Boivin et al.	Greater Montreal Area	662 twin pairs	5 months to 16 years	Yes	Birth records	Behavioral, social and cognitive development, and developmental health	DNA, Q, and chorionicity	Yes
China	The Chinese National Twin Registry	Liming Li et al.	National	35,000 twin pairs	All ages	Yes	Center for Disease Control and Prevention	Medical history, anthropometric measures, biochemical measurements, life style	DNA, Q	Yes
China	The Beijing Twin Study	Jie Chen et al. (Xinying Li)	Beijing	1,387 twin pairs	10–18 years	Yes	Schools	Psychopathology	DNA, Q	Yes
China	The Guangzhou Twin Project	Yingfeng Zheng (Mingguang He)	Greater Guangzhou area	Over 1,200 twin pairs and their family members	7–15 years	Yes	The Official Household Registry of Guangzhou City	Eye diseases, ophthalmic traits, and lifestyle	DNA, Q	Yes

TABLE 1

Continued.

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
China	The Qingdao Twin Registry	Haiping Duan et al. (Zengchang Pang)	Qingdao City, Shandong Province	10,559 twin pairs	All ages	Yes	Immunization registry for newborns, the tertiary prevention and health system, schools, and media	Anthropometric measurements, biochemical measurements, and health	DNA, and blood type	Yes
Cuba	The Cuban Twin Registry	Marcheco Teruel et al.	National	58,000 twin pairs	All ages	Yes	National citizen identity registry	Birth defects, common diseases, substance use/abuse, cancer, and mental disorders	DNA, Q	Yes
Denmark	The Danish Twin Registry	Axel Skytthe et al. (Kaare Christensen)	National	86,398 twin pairs	All ages	Yes	Birth registers, population registers, and medical birth registers	Health, diseases, survival, cognition, behavior, development, and aging	DNA, Q	Yes
England	G1219: A UK Twin Study	Tom McAdams et al.	National	1,381 twin pairs and 445 sibling pairs	12–19 years	Yes	Birth records, and participants of the previous study	Depression, anxiety, anxiety sensitivity, delinquent behaviors, sleep, and environmental experiences	DNA, Q	Yes
England	Twins Early Development Study	Claire Haworth et al. (Robert Plomin)	National	16,810 twin pairs	2–18 years	Yes	Birth records	Cognitive and behavioral development	DNA, Q	Yes
England	The UK Adult Twin Registry	Alireza Moayyeri (Tim Spector)	National	Approximately 12,000 twins	18–103 years	Yes	Media	Aging, complex diseases, and omics studies	DNA, Q	Yes
England	The Northern Survey of Twin and Multiple Pregnancy (NorSTAMP)	Svetlana V Glinianaia et al.	North East England	8,358 twin pairs and 226 sets of higher order multiples	0–14 years	Yes (a prospective survey; about 500 pregnancy data are added each year)	Recorded from the first antenatal scan and birth records	Prenatal, perinatal conditions, and childhood health	Chorionicity	No
Finland	The Genetics of Sexuality and Aggression Twin Samples in Finland	Ada Johansson et al.	National	10,624 twins and their siblings	18–49 years	Yes	The Population Register Center of Finland	Sexuality, aggression and related traits	DNA, Q	Yes
Finland	The Finnish Twin Cohort Study	Jaakko Kaprio	National	105,149 twins and their family members	10–100 year	Yes	The Population Register Center of Finland	Health and related behaviors, environment, morbidity and mortality	DNA, Q	Yes

TABLE 1

Continued.

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
Germany	The Bielefeld Longitudinal Study of Adult Twins	Christian Kandler et al.	National	2,404 twins	14–80 years	Yes	Media, twin club	Personality	Q	No
Germany	Current twin studies in Germany	Elisabeth Hahn et al.	National	Over 2,000 twin pairs	7–76 years	Yes	The government registration office, and existing studies	Personality, circadian rhythm, cognitive ability, motivation, and school achievements	DNA, Q	Yes
Germany	The Berlin Twin Registry	Andreas Busjahn	Berlin	1,744 twin pairs	All ages	Yes	Media	Health and related traits	DNA, Q	Yes
Guinea-Bissau	The Guinea-Bissau Twin Registry	Morten Bjerregaard-Andersen et al.	Bissau	1,500 twins	0–31 years	Yes	Hospital, demographic surveillance sites	Infections, malnutrition, diabetes, and metabolic syndrome	Q	Yes
Hungary	The Hungarian Twin Registry	Levente Littvay et al.	National	310 twin pairs	0–88 years	Yes	Twin meetings, website, media, and old volunteers registry	Cardiovascular and respiratory health, psychological variables	DNA, Q, and chorionicity	Yes
Israel	The Longitudinal Israeli Study of Twins	Reut Avinun and Ariel Knafo	National	Approximately 1,500 twin pairs	3–7 years	Yes	Birth records	Pro-social behaviors, empathy, temperament, and parenting	DNA, Q	Yes
Italy	The Italian Twin Register	Sonia Brescianini et al.	National	25,000 twins	All ages	Yes	Municipality records, disease registries, and hospitals	Perinatal conditions, pediatric health development, mental health, and aging	DNA, Q	Yes
Japan	The Keio Twin Research Center	Juko Ando et al.	National	Approximately 4,000 twin pairs	3–26 years	Yes	Resident register	Psychological and environmental variables	DNA, Q	Yes
Japan	The Osaka University Center for Twin Research	Kazuo Hayakawa et al.	National	12,000 twin pairs	20–95 years (mostly over 60 years)	Yes	School records	Diseases and related traits	DNA	Yes
Japan	Japanese Database of Families with Twins and Higher Order Multiples	Syuichi Ooki	National	About 5,000 twin and multiple families	0–52 years	No	Twin mothers' associations	Pre- and perinatal conditions, and childhood health	Q	No
Japan	The West Japan Twins and Higher Order Multiple Births Registry	Yoshie Yokoyama	Osaka, Nishinomiya City	7,000 twins and 4,300 higher order multiples	0–35 years	Yes	Twin mothers' associations, hospitals, media, and public health centers	Risk of disabilities in multiples, and physical development	Q	No

TABLE 1

Continued.

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
Japan	Lifecourse Database of Twins	Syuichi Ooki	Tokyo Metropolitan area	2,167 pairs and their family members	11–79 years	Yes	The secondary school attached to the University of Tokyo	Maternal obstetric data, and growth and development of multiples	DNA, Q	No
Korea	The South Korean Twin Registry	Yoon-Mi Hur et al.	National	Approximately 10,000 pairs	<30 years	Yes	Schools, hospitals, media, and childcare agencies	Mental health, personality, and cognitive abilities	Q, chorionicity	Yes
Korea	The Healthy Twin Study	Bayasgalan Gombojav et al. (Joohon Sung)	National	3,690 twins	29 years≤	Yes	Mailing based on population register	Complex traits and common diseases	DNA, Q	Yes
Malaysia	Malaysian Twin Registry	Shayesteh Jahanfar	National	470 twins	15 years≤	No	Hospitals, website, and schools	Reproductive health and well-being	Q	No
Mongolia	Mongolian Twin Register	Bayasgalan Gombojav et al. (Narandalai Danshiit-soodol)	National	822 twins and triplets	1–81 years	Yes	Birth records	Complex traits and common diseases	Q	No
The Netherlands	The Young Netherlands Twin Register	Catharina E. M. van Beijsterveldt et al.	National	70,000 children (mainly twins, but also siblings) and their parents	<18 years	Yes, 25 Years follow-up	Association for parents of multiples, commercial organizations, websites and social media	Development, phychopathology, cognitive and brain function, school performance, physical growth and health	DNA, Q	Yes
The Netherlands	The Adult Netherlands Twin Register	Gonneke Willemsen et al.	National	34,000 twins and family members (parents, siblings and spouses of twins)	18 years≤	Yes, 25 years follow-up	City council registers, NTR newsletter, media, websites and social media	Physical and mental health, lifestyle, personality, fertility, cognition and brain function	DNA, Q	Yes
The Netherlands	The Twin Interdisciplinary Neuroticism Study	Harriëtte Riese et al.	North of the Netherlands	Approximately 800 twin pairs	18–30 years	Yes	Birth records	Neuroticism, psychophysiological and cognitive measures, and basic blood tests	DNA, Q	Yes
Nigeria	The Nigerian Twin and Sibling Registry	Yoon-Mi Hur et al.	National	1,550 twins and siblings	<30 years	Yes	Schools	Mental health, personality, and cognitive abilities	DNA	Yes
Norway	The Norwegian Twin Registry	Thomas Nilsen et al. (Jennifer Harris)	National	47,989 twins	18 years≤	Yes	Medical Birth Registry, National Population Registry/Statistics Norway	Physical health, mental health, lifestyle, and demographic factors	DNA, Q	Yes
Portugal	Twin Research in Portugal	José Maia et al.	North of mainland, Azores and Madeira Islands	1,542 twin pairs	5–40 years	No	Schools, media advertisement, city halls, and twin meetings	Physical activity, physical fitness, physical growth, and metabolic syndrome	DNA, Q	Yes

TABLE 1
Continued.

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
Russia	The Russian School Twin Registry	Yulia Kovas et al.	National	Approximately 50,000 twin pairs	7–18 years	Yes	Schools	Cognition, emotion, motivation, achievement	DNA, Q	Yes
Spain	The Murcia Twin Registry	Juan R. Ordoñana et al.	Murcia	2,281 twins and triplets	40–67 years	Yes	Health records (Public Health System)	Anthropometric, health and health promotion-related traits	DNA, Q	Yes
Sri Lanka	The Sri Lankan Twin Registry	Athula Sumathipala et al.	National	16,580 twin pairs and 208 triplet sets	All ages	Yes	Door-to door visit survey, newsletters, cultural activities, media, birth records	Psychiatric disorders, and metabolic syndrome	DNA, Q	Yes
Sweden	Study of Dementia in Swedish Twins	Margaret Gatz and Nancy Pedersen	National	2,394 twins	55 years≤	Yes	Swedish Adoption/Twin Study of Aging	Dementia and its risk factors	DNA, Q	Yes
Sweden	The Swedish Twin Registry	Patrik Magnusson et al.	National	194,000 twins	9–106 years	Yes	The National Board of Health and Welfare	Behaviors, diseases, and aging	DNA, Q	Yes
Thailand	Thai Twin Registry	Somsong Nanakorn et al.	Central and Northeast	212 twin pairs	6–66 years	No	Schools and media	Dermatoglyphic variables	Q, blood type	No
Turkey	Turkish Twin Study	Sevgi Yurt Öncel et al.	National	618 twins	15–69 years	No	Birth records	Smoking and related traits	Q	No
USA	The National Longitudinal Study of Adolescent Health	Kathleen Mullan Harris et al.	National	784 twin pairs and 2,355 sibling pairs	12–32 years	Yes	Schools	Health and behaviors	DNA, Q	Yes
USA	The Project TALENT Twin and Sibling Study	Carol Prescott et al.	National	88,000 siblings and 2,500 twin pairs	14–29 years	Yes	Random sample of U.S. high schools	Cognition and related traits	Photograph	No
USA	The Early Growth and Development Study	Leslie Leve et al.	National	561 sets of families (adoptee, birth and adoptive parents)	0–9 years	Yes	Adoption agencies	Externalizing, internalizing behaviors, social competence, school performance, physical growth, & family environment	NA	Yes
USA	Fullerton Virtual Twin Study	Nancy Segal et al.	National	151 twin pairs	4–54 years	No	Media, investigator's website, and publications	Cognitive abilities	NA	No
USA	The Vietnam Era Twin Registry	Melyssa Tsai et al. (Alaina Mori)	National	7,369 male twin pairs and their family members	51–59 years	Yes	The Department of Defense and the Department of Veterans Affairs (VA) database files	Mental health, including PTSD, body mass index, diabetes, cardiovascular disease	DNA, Q	Yes

TABLE 1

Continued.

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
USA	The Vietnam Era Twin Study of Aging	William Kremen et al.	National	1,237 twins	51–59 years	Yes	The Department of Defense and the Department of Veterans Affairs (VA) database files	Cognitive and brain aging in men	DNA, Q	Yes
USA	Arizona Twin Project	Kathryn Lemery-Chalfant et al.	Arizona	600 twins	12 months, 30 months	Yes	Birth records	Development of early competence and resilience to common mental and physical health problems	Q, chorionicity	No
USA	California Twin Program	Wendy Cozen et al.	California	36,965 twin pairs	16 year<	Yes	Birth records linked to DMV	Medical history, lifestyle	Q	Yes
USA	The Southern California Twin Register	Laura Baker et al.	Southern California	782 sets of twins and triplets (n = 1,573 subjects)	9–20 years	Yes	Schools, and voter records	Antisocial behaviors and related traits	DNA, Q	Yes
USA	The Twin Research Registry at SRI International	Ruth Krasnow et al. (Gary Swan)	California (San Francisco)	3120 twins	All ages	Yes	Media	Drug metabolism, mutagen sensitivity, and human immunological responses	DNA, Q	Yes
USA	The Carolina African American Twin Study of Aging	Keith Whitfield	North Carolina	286 twin pairs, 31 sibling pairs, 72 co-twin missing cases	22–92 years	No	Birth records, and existing twin study	Mental and physical health	DNA, Q	Yes
USA	The Colorado Twin Registry	Sally-Ann Rhea et al. (Robin Corley)	Colorado	17,136 twins	1–31 years	Yes	Birth records	Cognition, learning disabilities, substance use, and psychopathology	DNA, Q	Yes
USA	The Colorado Adoption Project	Sally-Ann Rhea et al. (Robin Corley)	Colorado	1,004 subjects	25–52 years	Yes	Social service agencies, and hospitals	Cognition, substance use, and psychopathology	NA	NA
USA	The Florida State Twin Registry	Jeanette Taylor et al.	Florida	2,591 twin pairs	5–10 years	Yes	Schools	Reading, behaviors, and environments	Q	No
USA	The Southern Illinois Twins and Siblings Study	Lisabeth DiLalla et al.	Southern Illinois	291 twin and triplet sets, 98 sibling pairs, and 287 singletons	1–21 years	Yes	Birth records, newspapers, and referrals	Aggression, pro-social behaviors, parent–child interactions	DNA, Q	Yes
USA	The Boston University Twin Project	Kimberly Saudino and Philip Asherson (Kimberley Saudino)	Massachusetts	314 twin pairs	2–3 years	Yes	Birth records	Temperament and behavior problems with specific focus on activity level	DNA	Yes

TABLE 1

Continued.

Country	Name of twin registry (or running title)	Name of the first author (corresponding author)[a]	Region	Total sample size[b]	Age of the sample[c]	Longitudinal study?	Major recruitment methods	Major phenotype	Zygosity assessment methods[d]	Biospecimens/ DNA collected?
USA	The Michigan State University Twin Registry	Alexandra Burt and Kelly Klump (Alexandra Burt)	Michigan	Approximately 20,000 twins	3–30 years	Yes	Birth records, Michigan Department of Community health	Psychiatric and behavioral variables	DNA, Q	Yes
USA	The Texas Twin Project	K. Paige Harden et al.	Texas	Over 630 twin pairs	6–18 years	No	Schools	Academic achievement, personality, internalizing and externalizing problems, and environmental context	Q	No
USA	The Mid-Atlantic Twin Registry	Emily Lilley and Judy Silberg (Emily Lilley)	Virginia, North Carolina, and South Carolina	56,000 twins	All ages	Yes	Birth records, schools, hospitals, and events	Mental and physical health	DNA, Q, chorionicity, and anthropometric assessment	Yes
USA	University of Washington Twin Registry	Eric Strachan et al.	Washington State	7,200 twin pairs	18 years≤	Yes	The Washington State Department of Licensing application system	Mental and physical health	DNA, Q	Yes
USA	Wisconsin Twin Research	Nicole Schmidt et al.	Wisconsin	Approximately 6,000 twin pairs	3 months to 18 years	Yes	Birth records	Development of early emotion, child psychopathology and related topics	DNA, Q, chorionicity, and consensus ratings by observation	Yes
Int'l	International Twin Study	Wendy Cozen et al.	Canada and United States	17,245 twin pairs	All ages	Yes	Media	Cancer and chronic disease	Q	Yes
Int'l	IGEMS: The Consortium on Interplay of Genes and Environment across Multiple Studies	Nancy Pedersen et al.	Denmark, Sweden, and United States	17,587 twins and their family members	25–102 years	Yes	Birth and military records	Late-life mental and physical health; adult cognition and functioning	DNA, Q	Yes

Note: [a]Names of the corresponding authors are indicated in parenthesis when the first author is different from the corresponding author; for two-author papers, both authors' names are indicated.
[b]Twins = individual twins, including cases with missing co-twins. For most twin registers, the recruitment is ongoing and, therefore, the sample size is likely to change.
[c]Age at assessment or current age.
[d]Q = questionnaire, DNA = analysis of DNA markers, NA = not applicable.

well as improve our understanding of context-specific effects in the development of childhood temperament and behavior problems.

The Carolina African American Twin Study of Aging (CAATSA) was founded to study genetic and environmental influences on health and related traits in African Americans. CAATSA is, to our knowledge, the only twin registry in the world that focuses on African-American twins. The number of African-American twins who participate in twin registries in the United States (e.g., The Mid-Atlantic Twin Registry) is currently increasing in spite of the challenges with engaging ethnic minorities in scientific research. Together with twins who take part in twin studies in Africa, the CAATSA sample and other African-American twins in several registries in this issue may provide important information to develop optimal prevention and intervention strategies to reduce health disparities between people of African and European origin.

The Texas Twin Project was developed to address the question of whether and how family socioeconomic status (SES) and other environmental contexts can moderate genetic influences on psychosocial outcomes in children and adolescents. Taking advantage of the large population size and a high poverty rate in the state of Texas, the investigators were able to maximize representation of low SES families and racial/ethnic minorities in their sample. When the ascertainment of twin families is complete, the project will undoubtedly become an important resource to explore the effects of interactions between genes and social contexts on child development.

Prescott et al.'s article in this issue presents their plans to reassess 2,500 pairs of twins and approximately 90,000 siblings who participated in Project Talent (Flanagan, 1962) in the 1960s. In addition to a large, nationally representative sample, the availability of longitudinal data on families, schools, and communities, as well as students themselves, are great strengths of the sample, which will enable investigators to address the roles of environments in educational outcomes in a genetically sensitive design.

The adoption design is another major method to study the effects of genes and environments and their interplays on human behaviors and diseases. As it is important and necessary to compare and integrate the findings of adoption and twin studies to resolve many research questions, we invited two large, longitudinal adoption registries to report in this issue: the Colorado Adoption Project and the Early Growth and Development Study. The two papers presented their brief histories, the procedures and strategies to recruit and retain their samples, and their key findings to date.

An Overview of Twin Registries

The papers in this issue provide an overview of how twin registries can be developed and maintained, as well as various research questions that twin researchers are currently interested in (Table 1). While some papers discuss how twins can be used to address various research questions, others reviewed the main findings on the basis of their twin registries.

Twin registries cover all ages, with some recruiting before or at birth (e.g., Peri/Postnatal Epigenetic Twins Study [PETS], the Australian Twin Registry [ATR], The North of England Survey of Twin and Multiple Pregnancy, The East Flanders Prospective Twin Survey, the Italian Twin Register, and the West Japan Twins and Higher Order Multiple Births Registry) through to those focusing on all twins, as well as those focusing on older twins (e.g., the Osaka University Center for Twin Study, The Vietnam Era Twin Registry, the Carolina African American Twin Study of Aging, and the Consortium on Interplay of Genes and Environment across Multiple Studies [IGMES]), which extend to 102-year-old twins.

Sample sizes of twin registries in the current issue varied greatly, from a few hundred to close to 200,000 twins (the Swedish Twin Registry, the Danish Twin Registry). This issue shows that over 1.5 million subjects are now participating in twin studies around the world! Of note are several large nationwide twin registers in Northern Europe, which increase their sample sizes, representativeness, and research areas by linking their twin cohorts with national demographic, social, and health registers (the Danish Twin Registry, the Finnish Twin Cohort Study, the Norwegian Twin Registry, and the Swedish Twin Registry).

Many twin registries are currently carrying out longitudinal assessments, and some twin registries maintain impressively high retention rates over the years (e.g., The National Longitudinal Study of Adolescent Health).

Those readers wishing to establish new twin studies would do well to take note of some of the ingenious methods of recruiting: from the traditional media, birth records, immunization and other citizens' registries, schools, websites, voter records, military records, hospitals, twin clubs, twin mothers' associations, and even in the cases of the University of Washington Twin Registry and the California Twin Program, through the Department of Motor Vehicles. One population-based cohort used a 'negative consent' process, treating no response to a mail-out as a positive response and releasing information unless families actively opted out (Colorado Twin Registry). Other studies offered free zygosity tests (e.g., PETS, HealthTwiSt). A variety of methods were used to minimize attrition rates, through newsletters, mail-outs, and even social media (e.g., the Young Netherlands Twin Register). The Vietnam Era Twins Registry also set minimal 'respite periods' between visits and involved twins themselves in the planning of research topics.

While the majority of studies featured in this special issue focused on behavioral, psychiatric, and cognitive phenotypes, other well-studied areas include growth and development (Tokyo Twin Database; the Netherlands Twin Registry; the Quebec Newborn Twin Study); common physical diseases and their antecedents (the Chinese National Twin

Registry, Twin Registry of Guinea-Bissau; Hungarian Twin Registry; the Norwegian Twin Registry; Vietnam Era Twins Registry); aging (Danish Twin Registry, TwinsUK, Italian Twin Registry); and cancer (the Cuban Twin Registry; the International Twin Study of Cancer and Chronic Disease). Specialist topics include dentition (the Australian study of genetic, epigenetic and environmental influences on dentofacial structures and oral health), eyesight (Australian genetic studies into ophthalmic traits; the Guangzhou Twin Project), sexuality (Finnish study), physical activity (Twin Research in Portugal), fingerprints (the Thai Twin Registry), and drug metabolism and mutagen sensitivity (the Twin Research Registry at SRI International).

Most twin studies are now collecting biosamples from tissues such as blood, saliva, or the inner cheek and extracting DNA for genetic studies. As technology has progressed, genetic studies are moving from a focus on individual genes to whole genomes, and some studies have started to use these tools. DNA can also be used for the study of epigenetics, which describes the molecular factors that influence gene activity without changing primary DNA sequence, and which are stable but environmentally changeable. Epigenetic factors are beginning to explain some of the phenotypic discordance within monozygotic (MZ) twin pairs, and registries are either conducting (e.g., PETS, International Twin Study, and California Twin Program) or planning to conduct (e.g., Guangzhou Twin Project and Sri Lankan Twin Registry) such studies. Some twin registries are studying the effects of specific non-shared environments such as those encountered in utero, to begin to explain phenotypic differences within twin pairs (e.g., the East Flanders Prospective Twin Survey, the Peri/Postnatal Epigenetic Twin Study).

Finally, we return to the age-old question of how best to determine zygosity. A bewildering array of questionnaires is currently in use, based around questions about whether twins have ever been confused by others. For a definitive answer, many registries use genetic testing on genetically highly variable regions, but again there are many specific methods cited. Perhaps it is time for a consensus on this. What should also go hand in hand with recoding of zygosity is chorionicity, especially because it has been associated with pre- or perinatal mortality and postnatal morbidity (Derom et al., 2001). However, data on chorionicity are not easy to collect retrospectively, and even assessment pre- or postnatally is a highly skilled process. Knowledge of this skill needs to be spread more widely.

We hope you enjoy reading about the studies in this issue as much as we have.

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