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The Sri Lankan twin registry biobank: South Asia's first twin biobank

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Abstract

Introduction. Biobanks are a valuable resource for creating advancements in science through cutting-edge omics research. Twin research methods allow us to understand the degree to which genetics and environmental factors contribute to health outcomes.

Methods. The Sri Lankan Twin Registry biobank (SLTR-b) was established in 2015 as part of Colombo Twin and Singleton Follow-up Study. Venous blood and urine were collected from twins and comparative sample of singletons for clinical investigations and biobanking.

Results. The SLTR-b currently houses 3369 DNA and serum samples. Biobank specimens are linked to longitudinal questionnaire data, clinical investigations, anthropometric measurements, and other data.

Discussion. The SLTR-b aims to address gaps in health and genetics research. It will provide opportunities for academic collaborations, local and international, and capacity building of future research leaders in twin and omics research. This paper provides a cohort profile of the SLTR-b and its linked data, and an overview of the strategies used for biobanking.

Introduction

Twin research methods are genetically sensitive designs which allow researchers to understand the degree to which genetics and environmental factors contribute to variation (individual differences) in variables such as health outcomes. In addition, twin studies allow for associations between traits (disorders) to be quantified in parts due to shared genes and shared environmental factors.

Materials and methods

The Sri Lankan Twin Registry was established in 1997, and is the first ever twin register in South Asia [1]. It is still one of the few large-scale functional population-based twin registries in the developing world [2]. In 2007, twins from the registry and a comparative sample of singletons (non-twins) were recruited from Colombo district to conduct a cross-sectional study on mental health titled 'The Colombo Twin and Singleton Study' (COTASS 1) [3]. The study was a collaboration between the Institute for Research and Development, Colombo, Sri Lanka (IRD), the Institute of Psychiatry, Psychology and Neuroscience, Kings College London, UK, and Brain and Mind Centre, University of Sydney, Australia. COTASS 1 aimed to bridge a gap in genetic research on mental health in a low- and middle-income country by exploring the genetic and environmental factors involved in common mental disorders in the Sri Lankan population.

The same cohort was revisited in 2012 to conduct a multi-component study on mental health, metabolic syndrome factors, and other health and well-being variables (the Colombo Twin and Singleton follow-up Study – COTASS 2) [4]. The Sri Lankan Twin Registry biobank (SLTR-b) was established as a component of COTASS 2 with the aim to foster innovative epidemiological research. Participant recruitment lasted until the end of December 2015 for all components.

Setting

The COTASS cohort is based in the Colombo district which is a multi-ethnic and multicultural city [5]. Although being the country's capital, it is also the administrative and economic centre of the country. It is the most highly populated district in Sri Lanka with 2.4 million people comprising 11.4% of the country's population. Colombo has a mix of urban and rural areas with the majority being urban. The district is heavily urbanised and more westernised than other areas of Sri Lanka. The population is characterised by great socio-economic diversity in terms of education, employment, and occupational social class.

COTASS 2 comprised of three main study components: surveys, anthropometric measures, and biospecimen collection for clinical investigations and biobanking. This report is an overview of the outcomes, and proceedings of collecting, processing, and storing biospecimen data for the SLTR-b.

Minimising pre-analytical errors

Pre-analytical errors to ensure accurate laboratory results were minimised through careful collection and handling of biospecimens [6]. Similar care was taken with biospecimens collected for long-term storage for biobanking such that they would be usable for future downstream processes. A 4-h time frame for biospecimen collection and transportation back to the laboratory was maintained to reduce serum protein concentrations change over time [7, 8]. Pre-printed stickers with participant's unique identification number were used to label collected samples thereby avoiding unreadable or incorrectly written identification numbers. Standard operating procedures for biospecimen collection, storage, and participant preparation instructions for biospecimen collection were developed and optimised during the pilot phase. These minimised variations as biospecimens were collected from multiple sites which included clinical collection centres and house visits.

As infection, inflammatory processes, and medications may influence the outcome of certain blood investigations [9], participants were excluded from the clinical investigations' component if they (1) were on long-term medication which could interfere with the parameters under the study (e.g. steroids or other immunomodulatory agents); or (2) suffered from a comorbid inflammatory disease (e.g. chronic infections and autoimmune diseases). Pregnant participants and those suffering from an acute ailment or infection were revisited after delivery or recovery of illness, respectively.

Biospecimen collection

Overnight fasting blood and first morning mid-stream urine was collected contemporaneously from a single participant to measure a variety of clinical investigations and for biobanking (see Table 1 for details). Blood was collected using a vacuum extraction tube system (Becton Dickinson & Co Vacutainer System). Table 1 provides details of the collection order, preservative type, and volumes. Clinical investigations were outsourced to a private hospital in Colombo, housing an accredited laboratory.

Participants were given the options of (1) visiting the IRD; (2) visiting the main collection centre of the private hospital or one of their collection centres; or (3) have a research team visit their homes for biospecimen collection. Home visits were chosen by the majority of participants. The two teams conducting field

biospecimen collection included a phlebotomist and two research assistants; one of whom had a medical background and the other in charge of driving and navigation. A single team was able to visit between 10 and 15 participants on a single day in the morning. Participants were grouped into clusters based on their geographic proximity to each other. Therefore, each participant's overnight fasting time remained between 9 and 12 h. Passive containers with plastic transport racks stored inside rigifoam boxes layered with coolant gel packs were used for specimen transportation. Biospecimens collected from the satellite centres as well as at the IRD and by the research teams were transported directly to the main laboratory of the private hospital within the strict 4-h time frame.

Processing of biospecimens for clinical investigations and biobanking

Blood and urine samples intended for clinical investigations were processed by staff at the main laboratory. Blood and urine not used in clinical investigations was discarded. The 5 ml clot activator tubes were centrifuged and the separated serum (approximately 1.5–2 ml) was immediately divided into two equal aliquots. These were transferred into screw-top cryogenic vials using micropipettes and stored in a –80 °C freezer until further testing.

Guidelines for biobanking standards have not been developed for Sri Lanka as yet. Therefore, we adopted several international guidelines to ensure integrity and viability of DNA samples. DNA extraction from the whole blood samples was carried out at IRD's genetics laboratory using a Flexi Gene 250 DNA Purification Kit (Qiagen, Germany) under sterile conditions. DNA of each participant was divided into two equal aliquots and stored in 1.4 ml cryo-vials. The paired aliquots were stored in separate cryo-boxes and transferred back to the –80 °C freezer.

The quality/purity of the extracted DNA were controlled by measuring the absorbance (*A*) of every sample at 260, 280, and 230 nm spectrophotometrically and determining the A_{260}/A_{280} and A_{260}/A_{230} ratios. For samples of good quality, A_{260}/A_{280} is expected to lie in the range of 1.6–2.1. Lower values may indicate protein contamination whereas higher values may indicate a high content of RNA. At SLTR-b, the average ratio A_{260}/A_{280} in general is found to be 1.8 (± 0.2). The A_{260}/A_{230} ratio was used as a secondary measure of DNA purity. Expected A_{260}/A_{230} values for pure DNA are commonly within the range between 2.0 and 2.2. If the ratio is lower than expected, it may indicate the presence of contaminants such as proteins, Guanidine HCL (used for DNA extraction), EDTA, salts, or phenols. At SLTR-b, the average A_{260}/A_{230} ratio is found to be 2.0 (± 0.2). Integrity of DNA samples was assessed by agarose gel electrophoresis.

Clinical investigation reports

Original reports for clinical investigations were sent to participants whereas a digital copy was securely stored at IRD. We provided a cover letter which matched the participant's name to the identification number in the investigation reports. Body mass index (BMI), waist circumference, and blood pressure were included in this letter.

Table 1. COTASS 2 collected sample types, collection priority, volume, and purpose

| Order of collection | Type | Volume (ml) | Purpose |
|----------------------------|-------------------------|-------------|---|
| Fasting blood | | | |
| 1 | EDTA | 2.5 | Glycated haemoglobin |
| 2 | Clot activator (SST) | 3 | Lipid profile, SGOT ^a , serum insulin, serum creatinine, hs-CRP ^b |
| 3 | Clot activator (SST) | 5 | Serum isolation for biobanking |
| 4 | Fluoride | 2 | Fasting blood sugar |
| 5 | EDTA | 6 | DNA isolation for biobanking |
| First morning urine | | | |
| | Sterile specimen bottle | 10 | Urine creatinine, urine micro albumin, urine albumin-creatinine ratio |

^aSerum glutamic oxaloacetic transaminase.

^bHighly sensitive c reactive protein.

Biospecimen storage

Biobanking samples were labelled using cryogenic labels and stored in a large capacity -80 °C Forma 88600V freezer (Thermo Fisher Scientific, USA). A strictly controlled temperature is maintained to avoid unnecessary freeze-thaw cycles which may affect the levels of serum biomarkers [10] or yield of extracted genomic DNA [11]. During the biospecimen collection period, the freezer was initially stored in the main laboratory, which had backup generators and 24-h surveillance. The freezer was locked, and contents only accessible to authorised personnel of the COTASS 2 team.

In 2017, the -80 °C freezer and its content were transferred to the IRD's genetics laboratory while ensuring reliable power backup and greater security. A generator powered backup system was installed at IRD premises to ensure an uninterrupted power supply. It was coupled with a GSM power failure alarming system to alert the function of the power backup system using mobile short messenger service notifications.

Ethics and governance

COTASS 2 received ethical approval from the Faculty of Medical Sciences University of Sri Jayewardenepura, Sri Lanka Ethical Review Committee (reference number: 596/11), and the Psychiatry, Nursing & Midwifery Research Ethics Subcommittee, King's College London, UK (reference number: PNM/10/11-124). Data collection procedures and storage of biospecimens were in accordance with ethical standards of both institutional review boards, the ethical policies and practices of the IRD [12], and with the Helsinki Declaration of 1975. Informed written consent from all participants were obtained using two sections in the same form; one for each of the components of the main study including clinical investigations, and another section specifically designed for long-term storage of serum and DNA. Participants were over 18 years of age and could opt out of any or all of the components of COTASS 2. Participants were able to consent to (1) clinical investigations only, (2) DNA and serum storage for biobanking only, or (3) both clinical investigations and biobanking. Respondents visiting the IRD for biospecimen collection were provided with a simple meal to break their fast after sample collection. The main laboratory of the private hospital was provided with only the participants' unique identification number, age, and gender to maintain anonymity and confidentiality. Participants with clinical investigations indicating any departures from the

norm were advised to seek medical attention from the health centre nearest to them. The wide range of clinical investigations were a great benefit to many, who were attending diabetic or cardiovascular disease clinics. Ethical considerations for stored biospecimens are mentioned in the discussion section.

Results

Biospecimen collection was completed by the end of December 2014. DNA extractions were completed in February 2016, following which quality and integrity analysis of these samples continued for another 6 months and concluded in August 2016. Samples for biobanking and clinical investigations were collected from 3357 and 3464 participants, respectively. The high-participation rate was due to the availability of house visits and high standard of participant engagement by the FRAs.

There is a slight preponderance of females in the cohort. Participant ages range from 19 to 91 years (mean age: 42.81 years). The large majority of participants were of Sinhalese ethnicity (92.94%). There was a high participation from urban areas, and many respondents were unemployed and non-manual or skilled manual workers. One percent of respondents had no education, and the many participants (46%) had been schooled up to General Certificate of Education (Ordinary Level). The COTASS 2 sociodemographic details of participants are detailed in Table 2. Seventy-four percent of the participants are individual twins, as one singleton was recruited for every pair of twins in COTASS 1. The total overall number of individual twins for DNA and serum are 2485 and 2565 respectively, and 27% are opposite gender twins. Zygosity characteristics are presented in Table 3.

Anthropometric measures, blood pressure, clinical investigations, and longitudinal survey data are linked to the SLTR-b. Other data include heart rate variability data and actigraphy data from two sub-studies within COTASS 2. Table 4 provides details of all linked data, and Table 5 provides a list of selected COTASS 2 mental and physical health characteristics of participants in the SLTR-b and associations or mean differences between genders.

Discussion

'Research infrastructure is an indispensable component of research enterprise' [13]. New knowledge and innovation can only emerge from high-quality and accessible research

Table 2. Sociodemographic characteristics of COTASS 2 participants in the SLTR-b

| Characteristics | Biobanking component N = 3357 | | Clinical investigations N = 3464 | |
|--|----------------------------------|-------|-------------------------------------|-------|
| | n | % | n | % |
| Twin status | | | | |
| Singleton | 872 | 25.88 | 899 | 25.95 |
| Twin (individual) | 2485 | 74.02 | 2565 | 74.05 |
| Gender | | | | |
| Female | 1895 | 56.45 | 1958 | 56.52 |
| Male | 1462 | 43.55 | 1506 | 43.48 |
| Age | | | | |
| 19–29 years | 719 | 21.42 | 742 | 21.42 |
| 30–39 years | 863 | 25.71 | 898 | 25.92 |
| 40–49 years | 718 | 21.39 | 741 | 21.39 |
| 50–59 years | 580 | 17.28 | 596 | 17.21 |
| 60–69 years | 314 | 9.35 | 320 | 9.24 |
| 70+ years | 163 | 4.86 | 167 | 4.82 |
| Ethnicity ^a | | | | |
| Sinhala | 3093 | 92.94 | 3186 | 92.83 |
| Tamil | 103 | 3.09 | 106 | 3.09 |
| Muslim | 118 | 3.55 | 126 | 3.67 |
| Other | 14 | 0.42 | 14 | 0.41 |
| Urbanicity | | | | |
| Rural | 1339 | 39.89 | 1392 | 40.18 |
| Urban | 2018 | 60.11 | 2072 | 59.82 |
| Employment ^a | | | | |
| Unemployed, retired or student | 1432 | 43.33 | 1479 | 43.39 |
| Elementary occupations | 285 | 8.62 | 288 | 8.45 |
| Non-manual or skilled manual workers | 1335 | 40.39 | 1378 | 40.42 |
| Managers or professionals | 253 | 7.66 | 264 | 7.74 |
| Education level ^a | | | | |
| No education | 38 | 1.15 | 39 | 1.14 |
| Grade 1–5 | 235 | 7.09 | 236 | 6.91 |
| Grade 6 up to G.C.E. (O/L) ^b | 1530 | 46.18 | 1571 | 45.99 |
| Completed G.C.E. (O/L) Exam | 527 | 15.91 | 548 | 16.04 |
| Up to or passed G.C.E. (A/L) ^c Exam | 758 | 22.88 | 788 | 23.07 |
| University or higher | 225 | 6.79 | 234 | 6.85 |

^aContains missing data.^bGeneral Certificate of Education (ordinary level).^cGeneral Certificate of Education G.C.E. (advanced level).

infrastructures which include data resources, archives, and biobanks [14]. Biobanks are a valuable resource for creating advancements in science through cutting-edge omics research. However,

Table 3. Zygosity characteristics of twins (complete and incomplete pairs) of the SLTR-b

| Zygosity | DNA (%) | Serum n (%) |
|---------------------------|---------------|---------------|
| Monozygotic females | 605 (24.35) | 621 (24.21) |
| Monozygotic males | 467 (18.79) | 483 (18.83) |
| Dizygotic females | 405 (16.30) | 421 (16.41) |
| Dizygotic males | 316 (12.72) | 325 (12.67) |
| Dizygotic opposite gender | 692 (27.85) | 715 (27.88) |
| Total | 2485 (100.00) | 2565 (100.00) |

there is a scarcity of biobanks in the South Asian region. This may be due to a multitude of reasons including limitations in infrastructure, capacity, and sociological or ethical issues less common in Western settings. In addition, the lack of an overarching research culture in developing countries may be a systematic barrier, resulting in limited new knowledge output and capacity building within low- and middle-income countries. One of the main aims of setting up the IRD was to overcome this by helping to create an overarching research culture in Sri Lanka, and providing resources and infrastructure to local and international scientists.

COTASS 1 data have been shared for higher degree programmes locally and internationally. Until now, some COTASS 2 data have already been pooled into the CODAtwins project which is the largest international effort utilising the classical twin design [15]. Similarly, the newly established biobank is open for collaborative studies with academic institutions after research protocols have been accepted by the SLTR-b steering and ethics committees.

Human biospecimen collection for research and genetic studies are extremely sensitive matters especially in the developing world [16–19]. Unethical collection and exportation of biospecimens during events such as the 2004 tsunami [20] have made Sri Lankans apprehensive about biospecimen collection for research purposes. Ethical appropriateness varies between settings; understanding attitudes, views and beliefs of the community and stakeholders related to genomics research and biobanking is important [18]. We recently completed a qualitative study on public understanding of genomic medicine and research among SLTR-b participants [21]. Community engagement generates public trust which is of paramount importance. The IRD was awarded grants from Wellcome Trust, UK (2009) and the Medical Research Council, UK (2018) to engage twins in research through cultural activities.

Ethics forms a crucial cornerstone in the SLTR-b. Beliefs and values of our local communities played a major role in the method and types of biospecimens collected and stored, all of which must be taken into consideration. The IRD established policies and guidelines for the Sri Lankan Twin Registry [12] which conform to accepted international standards in genomic studies. The IRD's policy on human biospecimens is to analyse the data within a national institution or laboratory if the necessary infrastructure and technology exists. To address these concerns, the IRD's genetics laboratory was established during COTASS 1 as a strategic accomplishment from an ethical and infrastructure point of view [22], thereby avoiding the necessity for exportation biospecimens abroad. Broad consent was not obtained from COTASS 2 participants for biobanking. Therefore, any new

Table 4. Types of data linked to the SLTR-b from the longitudinal COTASS study

| Data type | COTASS 1 (2006–2007) | COTASS 2 (2012–2015) | DNA (N) | Serum (N) |
|--------------------------------|---|---|---------|-----------|
| Surveys | | | | |
| Sociodemographic data | Sociodemographic questionnaire | Sociodemographic questionnaire | 3357 | 3464 |
| Depression | Lifetime version of WHO-CIDI ^a Section E | 12-month version of section E of the WHO-CIDI | 3329 | 3433 |
| | | Beck Depression Inventory II | 3312 | 3416 |
| Post-traumatic stress disorder | WHO-CIDI Section K | 17 items PTSD Civilian Checklist | 3326 | 3430 |
| Anxiety | WHO-CIDI Section D | Generalised Anxiety Disorder 7 item | 3323 | 3427 |
| Somatic symptoms | Bradford Somatic Inventory | Bradford Somatic Inventory | 3357 | 3464 |
| Fatigue | Chalder Fatigue Scale | Chalder Fatigue Scale | 3357 | 3464 |
| Tobacco use | WHO-CIDI Section B | Tobacco Use questionnaire | 3357 | 3464 |
| Alcohol use | WHO-CIDI Section J | Alcohol Use Disorders Identification Test | 3326 | 3430 |
| Life events | The list of threatening experiences | The list of threatening experiences | 3324 | 3428 |
| Health and well-being | Short Form-36 Health Survey | Short Form 36 Health Survey | 3329 | 3442 |
| Twin zygosity | Zygosity determination questionnaire | Zygosity determination questionnaire | 2485 | 2565 |
| Closeness of twins | Not done | Closeness of twins questionnaire | 2438 | 2515 |
| Environmental stressors | Childhood experience of care and abuse questionnaire ^b | Not done | 3362 | 3362 |
| Suicidal ideations | Suicidal ideations questionnaire | Not done | 3362 | 3362 |
| Traumatic events | War and tsunami questionnaire | Not done | 3362 | 3362 |
| Social support | Not done | Multi-dimensional support scale questionnaire | 3323 | 3427 |
| Eating disorders | Not done | Eating disorders questionnaire ^b | 3329 | 3433 |
| Dietary habits | Not done | Diet and frequency of food groups ^c | 3338 | 3442 |
| Physical illnesses | Not done | A checklist of physical illnesses | 3327 | 3431 |
| Physical activity | Not done | International Physical Activity Questionnaire | 3312 | 3416 |
| Sleep | Not done | Pittsburgh sleep quality index | 3329 | 3433 |
| Other | | | | |
| Biochemistry | Not done | Clinical urine tests | 3352 | 3459 |
| | | Clinical blood tests | 3357 | 3464 |
| Anthropometric measurements | Not done | Height, sitting height, weight, waist circumference | 3330 | 3437 |
| Cardiovascular assessment | Not done | Resting blood pressure | 3333 | 3440 |
| | | Heart rate variability data ^d ♂ | 256 | 266 |
| Sleep and activity monitoring | Not done | Actigraphy ^e ♂ | 214 | 220 |

^aWorld Health Organisation – Composite International Diagnostic Interview.^bThe Dutch Eating Behaviour Questionnaire and the Three-Factor Eating Questionnaire were adopted for this eating disorders questionnaire.^cA questionnaire to measure the frequency of consumption of a comprehensive list of food groups in Sri Lanka.^dRecordings done on a Schiller Medilog AR12 Plus Holter Recorder at 1000 Hz.^eData collected using Phillips Actiwatch Spectrum.

♂ Data from twins only.

♂ Data from males only.

studies using SLTR-b specimens will require new ethical approval and consent from study participants as well.

The main strengths of the SLTR-b include the use of the twin design with a large population-based collection of DNA and

serum from twins and singletons. Biospecimens are linked to a variety of clinical biomarkers, physical measures, survey data on common mental disorders, other data, and a comprehensive set of confounders. We have been able to cover a wide age range,

Table 5. Selected COTASS 2 health characteristics linked to the DNA in the SLTR-b and associations or mean differences between genders

| | Females %/mean (n) | Males %/mean (n) | χ^2/t -test <i>p</i> value |
|---|-----------------------|---------------------|------------------------------------|
| <i>Mental health</i> | | | |
| Depressive symptoms | | | |
| None to mild | 55.28% (1670) | 44.72% (1351) | <0.001 |
| Moderate to severe | 68.87% (208) | 31.13% (94) | |
| PTSD | | | |
| No | 56.19% (1785) | 43.81% (1392) | 0.019 |
| Symptomatic | 65.63% (105) | 34.38% (55) | |
| <i>Anxiety</i> | | | |
| None to mild | 54.93% (1598) | 45.07% (1311) | <0.001 |
| Moderate to severe | 68.24% (290) | 31.76% (135) | |
| <i>Substance use</i> | | | |
| Smoking status | | | |
| Doesn't smoke | 64.87% (1898) | 35.13% (1028) | <0.001 |
| Current smoker | 1.35% (6) | 98.65% (437) | |
| Alcohol use | | | |
| No misuse | 64.94% (1889) | 35.06% (1020) | <0.001 |
| Misuse | 0.23% (1) | 99.77% (427) | |
| <i>Blood pressure</i> | | | |
| Systolic (mmHg) | 114 (1888) | 119 (1455) | <0.001 |
| Diastolic (mmHg) | 75 (1888) | 77 (1455) | 0.0002 |
| <i>Anthropometry</i> | | | |
| Height (cm) | 151.46 (1887) | 165.41 (1453) | <0.001 |
| Weight (kg) | 56.19 (1888) | 62.82 (1453) | <0.001 |
| Waist Circumference (cm) | 90.99 (1886) | 86.59 (1452) | <0.001 |
| BMI (kg/m^2) | 24.46 (1886) | 22.89 (1453) | <0.001 |
| <i>Biochemistry</i> | | | |
| Serum creatinine (mg/dl) | 0.74 (1904) | 0.98 (1465) | <0.001 |
| Total cholesterol (mg/dl) | 200.90 (1904) | 198.61 (1465) | 0.1053 |
| Low-density lipoprotein (mg/dl) | 127.31 (1904) | 123.02 (1465) | 0.0005 |
| Very low-density lipoprotein (mg/dl) | 22.42 (1904) | 28.69 (1465) | <0.001 |
| High-density lipoprotein (mg/dl) | 51.18 (1904) | 46.89 (1465) | <0.001 |
| Triglycerides (mg/dl) | 113.06 (1904) | 147.36 (1465) | <0.001 |
| Total cholesterol/HDL ratio | 4.03 (1904) | 4.36 (1465) | <0.001 |
| SGOT (U/l) | 22.73 (1904) | 29.43 (1465) | <0.001 |
| Serum insulin ($\mu\text{U}/\text{ml}$) | 13.45 (1902) | 13.07 (1465) | 0.5618 |
| Ultra-sensitive c-reactive protein (mg/l) | 3.60 (1904) | 2.95 (1465) | 0.0018 |
| Fasting blood sugar (mg/dl) | 108.49 (1904) | 106.29 (1465) | 0.1268 |
| HbA1c (%) | 6.05 (1904) | 5.90 (1465) | 0.0019 |
| Urine creatinine (mg/dl) | 84.12 (1900) | 128.23 (1464) | <0.001 |
| Urine microalbumin (mg/l) | 17.59 (1900) | 22.35 (1464) | 0.0195 |
| Urine microalbumin/creatinine (mg of albumin/g) | 34.63 (1900) | 30.95 (1464) | 0.6048 |

and the younger age groups provide an opportunity to understand disease development over future follow-up studies of COTASS. Weaknesses include the lack of clinical data from COTASS 1, and limited ethnic diversity. The cohort size of the SLTR-b is relatively small in comparison with other international biobanks such as the UK Biobank [23]. However, the SLTR-b was a component within COTASS 2, and therefore we believe we have done justice to the limited available funding. The biobank has limited geographic coverage (Colombo district only) and may limit generalisability to other populations.

In 2019, we received a Medical Research Council, UK grant to conduct a pilot study using the COTASS cohort (and their children) to disentangle genetic and environmental components of intergenerational risk transmission of nutritional choices on risk factors for cardio vascular disease. This is the first of its kind in a low- and middle-income country, and will use a children-of-twins design to identify the extent to which the association between parental and offspring nutrition is due to genetic and environmental transmission. The full grant is being applied for in 2020 and we shall be using DNA from the SLTR-b for GWAS to answer our research questions as well.

To conclude, the SLTR-b is a unique data-rich resource comprising genomic DNA and serum of twins and a matched sample of non-twins from Colombo, Sri Lanka. We have shown that large-scale research infrastructure development is possible in low- and middle-income countries through North–South collaborations. This is the ‘first of its kind’ biobank establishment in South Asia which will allow us to answer complex research questions, whereas aiming to address gaps in health and genetics research. It will provide opportunities for further academic collaborations local and internationally, and capacity building of future research leaders in twin and omics research. The future goal of the IRD is to create a nationally representative repository of biospecimens for use in innovative epidemiological research providing new insights into diseases burdening the region.

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Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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