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THE CEMENTERIO NORTE OSTEOLOGICAL COLLECTION: A NEW DOCUMENTED SKELETAL SERIES FROM ARGENTINA

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Abstract

Documented osteological collections are a fundamental resource for bioanthropological research, enabling the development and validation of methods for sex and age-at-death estimation, palaeopathological differential diagnosis, and the study of human biological variability. This paper describes the formation, current composition, and preliminary characterization of the Cementerio Norte Osteological Collection, a newly assembled identified skeletal series from the municipal cemetery of San Andrés de Giles, northeast of Buenos Aires Province, Argentina. The collection currently comprises 65 individuals (32 female, 33 male) with ages at death ranging from one day to 90 years ($\bar{x}$=55.54 years, SD=24.32), who died between 1909 and 1993. Reliable antemortem documentation is available for every individual, including name, sex, age, dates of birth and death, nationality, and cause of death; for a subset of cases, kinship relations are also documented. Remains were recovered using archaeological excavation techniques, and laboratory processing followed a comprehensive collection-management plan comprising ventilation, mechanical cleaning, drying, labelling, inventory, osteological analysis, database creation, and long-term storage under controlled environmental conditions. Particular attention was paid to bioethical considerations, including confidentiality of personal data through dissociation of documentary information from skeletal remains, respectful treatment of the individuals, and compliance with current legislation. This collection constitutes a robust, well-contextualized reference resource for bioarchaeological and forensic anthropological studies, complementing other documented series in Argentina and offering chronological continuity with the neighboring Cementerio Sud bioarchaeological sample.

KEYWORDS

Reference human sample, forensic anthropology, bioarchaeology, bioethics, biological profile.

Highlights

A new documented skeletal series from Argentina is presented.

Collection comprises 65 individuals with documented sex, age, and cause of death.

Balanced sex ratio and wide age range aid sex and age method validation.

Documented kinship enables familial trait heritability and resemblance studies.

Ethical dual-database ensures confidentiality and regulated scientific access.

INTRODUCTION

Documented human osteological collections (i.e., assemblages of human skeletal and dental remains linked to reliable antemortem biographical information such as sex, age at death, cause of death, nationality, occupation, and kinship) are among the most valuable resources available to bioarchaeology and forensic anthropology [1-3]. These series allow researchers to test the accuracy and precision of methods used to reconstruct the biological profile under controlled conditions that cannot be replicated using samples lacking reliable documentation for each individual [4-5]. This line of work has produced sustained scientific output. Reviewing 376 indexed publications between 1969 and 2021, Alves-Cardoso and Campanacho [1] reported marked growth in the creation of documented collections from 2008 onward, with further acceleration after 2013; sex and age-at-death estimation, paleopathological research and the study of human phenotypic variability are the dominant research areas associated with them.

Historically, the earliest and most widely cited identified series were assembled in Europe and the United States, largely from the late eighteenth century onward [6]. Notable examples include the Hamann-Todd Collection in Cleveland and the Terry Collection in Washington D.C., both established in the early twentieth century [7,8]; the Coimbra Identified Skeletal Collection in Coimbra, Portugal, and the Collection of Identified Human Skeletons at the National Museum of Natural History and Science in Lisbon, Portugal, dating to the end of the nineteenth and the beginning of the twentieth centuries [9-11]; and the Spitalfields Collection in London, dating to the late eighteenth and nineteenth centuries [12,13]. More recent series from Europe include the Granada Collection of identified infants and young children in Granada, Spain [14], the series of the Certosa Cemetery in Bologna, Italy [15,16], the more recent 21st Century collection at the University of Coimbra, Portugal [17], and the Winthir Collection from Munich, Germany, notable for its substantial non-adult component [18]. Also noteworthy is the Pretoria Bone Collection in Pretoria, South Africa [19]. These boosts reflect both a sustained demand for population-specific reference samples and the diversity of contexts in which documented remains can be lawfully recovered, thereby broadening the range of human diversity available for analysis.

Despite this expansion, the global distribution of documented collections remains markedly uneven. The Forensic Anthropology Society of Europe catalogued 153 identified osteological collections across 41 countries, only 43 of which were classified as contemporary (composed wholly or partly of individuals born after 1920) [5]; most are concentrated in Europe and North America, whereas Africa, Asia, and especially South America remain considerably underrepresented [2]. Consequently, concerted efforts are currently undertaken to develop documented human osteological collections in South America, deepening the informational base for scientific research. Since skeletal and dental phenotypic variability results from the synergistic interaction between genetics and population-specific environmental and cultural conditions, including nutrition, physical activity, secular trends, disease, and socioeconomic status [20], methods developed on North American or Western European reference samples cannot be assumed to offer comparable accuracy when applied to skeletal samples from other regions [21-24]. This constitutes both a methodological and an epistemological bottleneck for regional forensic practice and bioarchaeological interpretation, one that can only be addressed through systematic validation of existing methods, and, where necessary, the generation of new population-specific standards, using local documented samples [19,25-29].

In Argentina, forensic and bioarchaeological research has historically relied on methods and standards derived from foreign documented collections, generally without prior local validation. For adult sex estimation, escopic assessment of the pubic bone proposed by Phenice [30] and the cranial morphological method of Acsádi and Nemeskéri [31] remain widely used, while age-at-death estimation continues to depend primarily on the pubic symphysis methods of Todd [32,33], McKern and Stewart [34], Gilbert and McKern [35], and Brooks and Suchey [36], the auricular surface methods of Lovejoy and coauthors [37], the fourth rib method of İşcan [38], and the cranial suture-closure method of Meindl and Lovejoy [39]. To counteract this reliance on non-local standards, over the past decades several Argentine research teams have begun to assemble their own identified skeletal series. Under the Chacarita Project, based at the Chacarita Cemetery in the city of Buenos Aires, approximately 250 skeletons were recovered under fully archaeological, research-team-controlled conditions [25,28,40]. Other documented samples include the Prof. Dr. Rómulo Lambre Collection, curated at the Faculty of Medical Sciences of the National

University of La Plata, which currently comprises more than 400 individuals, comprising both adults and non-adults [41]. More recently, additional regional initiatives have emerged, including the Necochea-Quequén Collection [42], the Mendoza Osteological Collection for Scientific and Forensic Research [43], a documented series from the General San Martín Municipal Cemetery [44], and a North Patagonian osteologic collection [45]. Comparable efforts are also being taken elsewhere in South America, as shown by the osteological collection of Santiago de Chile [46] and several samples from Brazil [47], redressing the continental imbalance highlighted by Plens and colleagues [48].

Within this expanding regional landscape, the Bioarchaeology and Forensic Anthropology Research Unit (UIBAF; Unidad de Investigación en Bioarqueología y Antropología Forense[1]), based at the Institute of Public Health Research (IISAP) and the Chair of Endodontics, Faculty of Odontology, University of Buenos Aires (FOUBA), undertook the parallel development of two documented skeletal collections from municipal cemeteries in the northeastern Buenos Aires Province. The first, named Lobos Collection, comprises 28 individuals (11 female, 17 male) recovered from marble and wooden urns housed in family vaults of the Lobos Municipal Cemetery (Buenos Aires, Argentina), dating from the second half of the nineteenth and the early twentieth centuries, and thus corresponding to the period of most intense transatlantic immigration to Argentina. This collection is particularly notable because it includes the most ancient documented individuals in Argentina and thus allows documentation of the phenotypic characteristics of the regional population during the pre-antibiotic era [49]. This paper introduces the second of these documented series, the Cementerio Norte Osteological Collection (CNOC), recovered from the Northern Cemetery of San Andrés de Giles (SAG), Buenos Aires Province. Its aims are fivefold: 1) to describe the historical background of the cemetery, including its immediate predecessor, the Cementerio Sud (Southern Cemetery), an archaeological burial ground excavated by the same research team; 2) to present the legal and administrative framework and the field and laboratory protocols that enabled the ethical recovery of the skeletal remains; 3) to provide a preliminary demographic and epidemiological characterization of the collection; 4) to

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discuss the bioethical principles that guide all stages of the project, including the comprehensive collection-management plan implemented to minimize deterioration and ensure long-term preservation; and 5) to outline future lines of research, with particular emphasis on the generation and validation of methods for sex and age-at-death estimation in adults and non-adults.

HISTORICAL AND ARCHAEOLOGICAL CONTEXT

The municipal district of SAG is located in northeastern Buenos Aires Province, approximately 100 km from the Autonomous City of Buenos Aires (Figure 1). It lies within a region of historical significance for both the consolidation of the Argentine national state and for the transatlantic migratory currents of the late nineteenth and early twentieth centuries. The town, founded in 1806, experienced substantial demographic growth during the end of the nineteenth century, driven mainly by the arrival of large numbers of immigrants, predominantly from Italy, Spain and Ireland, who settled in the surrounding countryside and engaged in agriculture, livestock-raising, and commerce [50-52]. The rise in epidemic outbreaks, resulting from inadequate sanitary and housing conditions for accommodating such a large immigrant population, together with concomitant population growth, produced a profound demographic transition. This process mirrored the broader transformation of the Pampean region during a period when Argentina received one of the largest proportional flows of European migrants recorded anywhere in the world, fundamentally reshaping the demographic and epidemiological profile of the local population [53].

The Northern Cemetery was preceded by four earlier burial grounds; the first three were much smaller, short-lived, established during the town's first decades. The fourth, named Cementerio Sud (Southern Cemetery), was founded on Easter Monday 1874 on a one-hectare quadrangular plot located 3 km southeast of the town, and abandoned in 1919, when its capacity was exhausted; it received the remains of local residents and immigrants of diverse origins, many of whom died during outbreaks of cholera, smallpox, and yellow fever during this period [54,55]. Previous archaeological research conducted by the team at this site recovered a substantial assemblage of skeletal remains, which provides valuable information on living and dying conditions in the locality [56]. Crucially, most of the

individuals inhumed in the Cementerio Sud were direct ancestors of individuals later buried in the Cementerio Norte. The latter was established in 1916 in response to the continued local population growth and the consequent need for a bigger burial ground. Since then, it is the locality's main cemetery, accommodating both traditional earth burials, and family vaults and wall niches. The chronological cemetery span effectively extends the observational window opened by the Cementerio Sud sample by more than a century, offering the opportunity to examine demographic variation and secular changes in morphology, health, and mortality patterns over a period encompassing the consolidation of Argentina's modern demographic and epidemiological regime.

SAMPLE AND METHODOLOGY

Provenance of the remains, field recovery protocol, and laboratory processing

The CNOC skeletal assemblage derives from two distinct depositional contexts: wall niches sealed with marble slabs, which contained both wooden coffins with lead-lined interiors and urns, and earthen pit graves, consisting of coffins inhumed directly within the sedimentary matrix. Individuals were selected for incorporation into the collection according to four main criteria: 1) availability of reliable antemortem documentation, prioritizing cases with complete death certificates recording full name, dates of birth and death, age, sex, nationality, and cause of death; 2) expiry of usage rights, limited to plots for which the legally mandated notification of relatives had been completed without any expression of interest in renewal (see below); 3) state of preservation, prioritizing well-preserved and complete skeletons while not excluding cases of differential preservation of taphonomic interest; and 4) demographic composition, seeking to include individuals of both sexes and diverse age ranges whenever possible.

Exhumation was conducted by an interdisciplinary team of archaeologists, biological anthropologists, forensic anthropologists, and odontologists, in accordance with the basic principles of archaeological excavation protocol [57-59]. Recovery was performed exclusively by trained members of the research team in order to maximize the contextual information recorded and to safeguard the physical integrity of the remains. The field protocol comprised six sequential stages: 1) location and preparation involved identification of the plot to be exhumed through cemetery documentation, verification of coordinates, and

initial photographic recording; 2) for earth burials, the overlying sediment (approximately 2 m^3 per plot) was removed with the collaboration of cemetery staff using shovels and pickaxes, until the estimated burial depth was reached; for remains deposited within above-ground niches, removal consisted instead of lifting the corresponding niche covers; 3) controlled excavation was conducted with precision tools (trowels, spatulas, brushes, and wooden picks) enabling careful exposure of the remains without damage; removed sediment was screened through a 5mm mesh to recover small skeletal elements, teeth, and associated objects; 4) documentation comprised photography at every stage, recording of sediment characteristics and observed taphonomic processes (e.g., root action, bioturbation), and sediment sampling for future analyses; 5) extraction comprised the individual removal of each element, superficial cleaning of adhering sediment with soft brushes, and placement in labelled bags. 6) In the final stage, all elements from the sale individual were placed in a single, properly identified cardboard box and transported to the laboratory for processing.

At the laboratory, remains underwent a standardized conservation and documentation sequence implemented following criteria established by Aranda and colleagues [60,61] and broadly consistent with international guidance on the preventive conservation and ethical management of osteological collections [62,63]. This sequence also comprised six stages: 1) ventilation in a stable, light-protected environment, during which bags containing the remains were opened, exposing them to air for 48-72 hours to reduce moisture levels and inhibit fungal and microbial proliferation; 2) mechanical cleaning of each element with soft-bristled brushes and, when necessary, water, avoiding chemical agents that could alter bone composition and compromise future analyses (e.g., isotopic, genetic); 3) drying, in which cleaned elements were placed on absorbent paper at room temperature for at least two weeks, with periodic rotation to ensure uniform aeration (a critical step for preventing fungal growth and ensuring the long-term stability of the sample); 4) labelling, in which, once completely dry, each skeletal element was marked with an identification code using fine-point permanent ink marker; 5) inventory, comprising a detailed record of the skeletal and dental elements present, laterality, state of preservation, pathological conditions, and evidence of anthropic or taphonomic affectation; and 6) storage, in which bones and teeth were included in acid-free, high-density polyethylene bags, grouped by anatomical region,

deposited in cardboard boxes individually labelled with the corresponding identification code, and stored on metal shelving within a space maintained at controlled temperature (18-22°C) and relative humidity (40-60%), with continuous ventilation to prevent fungal growth and moisture accumulation, alongside routine measures to prevent insect and rodent infestation.

Associated cultural material was separated from the human remains and stored in other boxes to prevent damage from friction or pressure. A management system was implemented to record each element entering or leaving the collection, along with all consultations and studies undertaken, thereby ensuring full traceability of activities carried out on the assemblage. Any material temporarily transferred for non-destructive analysis (e.g., micro-computed tomography), together with the resulting data, is returned to the custodial institution at the earliest opportunity. Priority is given to non-destructive analytical approaches; when destructive sampling is required (e.g., for DNA or stable isotope analysis), the scientific justification is carefully assessed and the quantity of extracted material minimized so as not to compromise the integrity of the collection [64].

Information management and confidentiality

The management of documentary information associated with the collection is a central component of the project, particularly regarding the protection of personal data. Firstly, to avoid revealing the identities of the individuals comprising the collection, each was assigned a sequential numeric code, allowing the location of every anatomical element to be traced without violating the principle of anonymization. Then, a dual-track system was implemented to ensure the dissociation of skeletal remains from identifying information. A restricted database contains the complete documentary record for each individual (i.e., identification code, full name, dates of birth and death, age, sex, nationality, cause of death, occupation, address, and kinship relations) and is accessible exclusively to the project's principal investigators. A research database, by contrast, contains only information relevant to scientific purposes: identification code, sex, age, cause-of-death, preservation indicators, and recorded osteological variables. Subject to established institutional access procedures and applicable ethical and legal requirements, this database may be made available to the broader scientific community for research purposes. This system is consistent with the

recommendations of bodies such as the International Council of Museums [62] and with the ethical principles established in the Declaration of Helsinki for research involving human material [65].

Statistical analysis

The data generated to date were analyzed here using measures of central tendency and variability. Means, standard deviations, minimum and maximum values, and the 25th, 50th and 75th percentiles were calculated by sex and age-at-death using SPSS 23.0. Frequency distributions were examined by sex, birth decade, death decade, and cause-of-death categories. The latter were grouped according to standardized broad diagnostic criteria [66]: diseases of the circulatory, respiratory, digestive, central nervous, and urinary systems; neoplasms; infectious diseases; trauma; and other causes.

RESULTS. CHARACTERIZATION OF THE COLLECTION

The CNOC currently comprises a total of 65 individuals (32 females, 49.23%; 33 males, 50.77%). Individuals were born between 1849 and 1984 (Table 1; Figure 2), with the best-represented decades being 1900-1909 (n=10; 15.38%), 1890-1899 (n=9; 13.84%), and both 1870-1879 and 1880-1889 (n=8 each; 12.31%). A substantial proportion of individuals were therefore born during the period of intense European immigration to Argentina (approximately 1880-1920), consistent with the demographic composition of the region. Deaths occurred between 1909 and 1993 (Table 1; Figure 3), with the highest frequencies concentrated in 1930-1939 and 1950-1959 (n=13 each; 20.00%), followed by 1910-1919 (n=9; 13.85%) and 1920-1929 (n=7; 10.77%).

The age-at-death profile of the total sample ranges from one day to 90 years, with a mean of 55.54 years (SD=24.32 years; 25th percentile=43 years; 50th percentile=62 years; 75th percentile=72 years; Table 2). Sex-specific analysis reveals a slightly higher mean age at death for females (57.72 years; SD=21.98) than for males (53.42 years; SD=26.41). The youngest documented individuals are a female aged 42 days and a male aged one day, while the oldest female and male are 90 and 87 years old, respectively. As shown in Table 3 and Figure 4, the age distribution is concentrated in the 60-69 (n=16; 24.61%), 70-79

(n=12; 18.46%), and 80-89-year (n=7; 10.77%) years-old cohorts. Notably, individuals over 60 years account for 55.38% of the collection.

Complementing this demographic framework, accurate cause-of-death data are available for 47 individuals (72.31% of the sample) (Table 4; Figure 5). Circulatory diseases and neoplasms constituted the two most frequent categories, each representing 25.53% of deaths (n=12). Among circulatory conditions, congestive cardiac failure was the most common specific diagnosis (n=5; 10.64%). Neoplastic causes are more diverse, with gastric and pancreatic carcinomas recorded both in two cases (4.26%), and breast carcinoma, oesophagus, liver, and intestine in a single individual each (2.13%). Respiratory conditions accounted for 12.77% of deaths, predominantly acute pulmonary oedema and pneumonia (n=4; 8.52), while infectious diseases (8.52%) comprised pulmonary tuberculosis (n=3; 6.39%) and one case of septicaemia of nasal origin (2.13%). Trauma was responsible for 4.26% of deaths, involving a gunshot wound to the head and a basilar skull fracture from a vehicular accident, both in females. Overall, this cause-of-death profile, dominated by circulatory and neoplastic conditions rather than infectious or epidemic causes, is consistent with Argentina's twentieth-century epidemiological transition [67] and contrasts markedly with the infectious-disease burden observed in the earlier nineteenth-century sample from the Lobos Collection [49].

The collection comprises individuals of diverse geographic origins. Most are Argentine (n=49; 75.38%), with additional cases of Italian (n=6; 9.23%), Spanish (n=2; 3.08%) and French (n=1; 1.54%) nationality; this information could not be determined in seven cases (10.77%). Moreover, the last names of most individuals suggest family origins linked to Western European populations, underscoring the sample's heterogeneous immigrant composition.

Another particularly valuable aspect of the collection resides in the documentation of kinship relations among several individuals. Cross-referencing the available documentary records has thus far revealed ten distinct family groupings, including father-son, mother-daughter, and multi-generational relationships. Several of these comprise three or four individuals, for example, a mother with three adult children, or a married couple with one or two children. Such genealogical detail is exceptionally rare in documented osteological collections worldwide, affording unique opportunities to investigate familial resemblance in

morphological and pathological traits, as well as the heritability of discrete skeletal and dental traits, a line of inquiry that remains largely unexplored in South American collections.

A preliminary assessment of skeletal preservation and completeness indicates that the collection is generally well preserved, with most skeletons complete or highly complete. The principal taphonomic agents identified so far include: 1) post-depositional fractures resulting from sediment pressure and exhumation; 2) manganese and iron-oxide staining on elements exposed to humid microenvironments; 3) loss of small skeletal elements (e.g., distal phalanges, middle-ear ossicles, carpals); and 4) superficial calcium carbonate (lime) deposits applied as part of mortuary practices. A systematic taphonomic study will allow detailed characterization of the specific agents involved and their diagenetic implications.

DISCUSSION

The CNOC occupies a particularly valuable position within both national and international contexts of documented osteological collections for several reasons. Its balanced sex distribution constitutes a significant advantage, as many documented series worldwide exhibit a marked male bias that can systematically skew the training and validation of sex-estimation methods [6,19,68]. Moreover, its wide age range permits the study of morphological changes across the lifespan within a single, internally consistent series. The high proportion of individuals over 60 years represent a substantial demographic component, particularly relevant for research on age-at-death estimation among older adults, one of forensic anthropology's most persistent challenges, as existing methods often yield highly inaccurate results for this cohort [3,25,26,27,69-72].

In addition, the associated documentation is exceptionally rich, encompassing not only basic demographic data but also nationality, occupation, cause of death, and, for a subset of individuals, kinship ties. This extensive information supports research avenues extending well beyond biological-profile estimation, such as exploring the relationship between occupation and musculoskeletal stress markers, correlating documented causes of death with observed skeletal lesions, and investigating the heritability of morphological traits. Perhaps most exceptional, however, is the documented kinship network identified among several individuals, which represents a very scarce resource globally and enables research

into familial resemblance in skeletal morphology and pathology that few other collections can support.

The importance of the collection is not limited to its intrinsic characteristics; it is further enhanced by its relationship with other regional osteological series. It is part of an expanding constellation of documented Argentine collections and, most directly, is linked to the Lobos Collection [49], which, although earlier, shares a comparable geographic provenance. The coexistence of these series across diverse temporal and spatial contexts provides a robust comparative framework for investigating regional human phenotype variability and temporal change, affording analytical opportunities beyond the reach of any single collection.

Particularly noteworthy is the chronological and geographic complementarity between this collection and the Cementerio Sud archaeological site [56], the historical cemetery preceding the Cementerio Norte. Whereas it documents the population characteristics of the late nineteenth and early twentieth centuries, the Cementerio Norte extends this period up to the present day. This near 150-year temporal continuum, anchored in a single locality, will enable investigation of changes in skeletal morphology, health, and demography over a span that remains exceptional within South American bioarchaeology.

Bioethical aspects and responsible management

The assembly and curation of human osteological collections pose significant ethical challenges that have attracted increasing attention [25,73-76]. These concerns are particularly salient in documented collections, where personal information is directly linked to the remains. Accordingly, the development of CNOC is guided at every stage by the following ethical principles, in accordance with international recommendations [62,65] and the professional codes of ethics of the Argentine Biological Anthropology Association (AABA) [77], the American Association of Physical Anthropologists (AAPA) [78] and the British Association for Biological Anthropology and Osteoarchaeology (BABAO) [64]:

1. Lawful provenance and consent. All individuals in the collection originate from plots for which the complete administrative process mandated by municipal regulations has been fulfilled. Recovery was carried out under the municipal regulatory framework, which

establishes the procedures for notifying relatives of the expiration of usage rights. In every instance, the following sequence was completed: 1) verification that plot usage rights had expired; 2) publication of edicts in the municipal bulletin and a local newspaper, notifying relatives of the expiration and of the possibility of proceeding to exhumation; 3) confirmation that no response had been received from authorized representatives within the legally established periods; 4) formal release of the remains by the cemetery authorities; and 5) execution of a donation agreement between the cemetery and the UIBAF, establishing the terms for the transfer of the remains for scientific purposes. This protocol aligns closely with international recommendations for the ethical assembly of osteological collections, which emphasize that the incorporation of human remains into research samples must occur with due respect for legal norms and for the wishes of relatives, thereby rendering the recovered material eligible for donation to scientific research upon completion of all administrative formalities. This procedure guarantees legal compliance and respect for family rights [75,76].

2. Confidentiality and data protection. The dual-database system described above ensures that personal identifying information is stored separately from the skeletal remains. Full access to the complete dataset is restricted to the principal investigators; all other researchers are permitted to work exclusively with anonymized, aggregated data.

3. Respectful treatment. All handling procedures are conducted with the respect owed to the deceased. Project personnel receive specific training in the ethical dimensions of their work and are instructed to maintain a professional approach throughout all stages of recovery, processing, and storage, prioritising the dignity of the individuals concerned and respect for their remains [63,77,79].

4. Restitution of remains. Any future claim by a relative for the return of individuals already incorporated into the collection will be honoured immediately and unconditionally. The remains will be returned for reburial or cremation at the claimant's decision, irrespective of the status of any ongoing research. This commitment constitutes a cornerstone of the project's bioethical protocol and is fully consistent with current international standards on consent and restitution.

5. Preservation and future access. The collection is housed under controlled environmental conditions to support its long-term preservation and future accessibility. A preventive

conservation plan has been developed in accordance with established criteria for bioanthropological collections [60,61,63,80] and includes regular monitoring of storage conditions as well as emergency-response protocols.

6. Regulated access. Research access to the collection is subject to approval by the project directors. Prospective researchers must submit a detailed protocol outlining their objectives, methods, and procedures, together with the measures adopted to ensure data confidentiality. Destructive sampling is discouraged unless a robust justification is provided. Any materials or data generated through non-destructive external analysis must be returned to the custodial institution.

7. Community engagement and restitution of knowledge. The project includes provisions for the restitution of research findings to the local community through outreach initiatives and engagement with educational and cultural institutions in SAG.

Taken together, these principles align with the consensus standard articulated for the ethical use of unclaimed and donated human skeletal remains in forensic anthropological research, education, and training [75]. A decade of engagement with the community of SAG has fostered a profound awareness of these issues within the research team, closely mirroring the experiences reported by Cardoso [74] and Squires and colleagues [76]. This awareness also reflects a broader recognition that scientific interest in human remains must be continually balanced against the rights, expectations, and sensitivities of the communities and, where identifiable, their descendants.

Limitations

Despite its considerable value, the collection presents some limitations that warrant explicit acknowledgment. The most evident is that, comprising 65 individuals, the collection is moderate in size, adequate for many analyses, yet potentially restrictive for studies requiring stratification by sex or narrow age cohorts. Population representativeness poses a second limitation. As with any cemetery-derived assemblage, the collections do not necessarily reflect the once-living regional population structure, and the individuals included may be subject to biases linked to the socioeconomic circumstances that precluded family claims on their plots and to the preferential claiming of individuals younger than 40

years old [4,25,68]. Documentary completeness is also uneven; records for some individuals remain partially incomplete (e.g., undetermined nationality, names of parents or spouse, and only a general cause of death), thereby reducing the sample availability for certain analyses. Finally, although preservation is generally good, it varies across individuals; in consequence, completeness and preservation status must be taken into account when selecting cases for particular studies. Several measures are being implemented to address these shortcomings. First, continued exhumation is planned to increase sample size progressively, with particular attention to underrepresented age cohorts to achieve a more balanced age-at-death distribution. Second, additional documentary research is being pursued through cross-referencing with civil registry death records. These ongoing efforts are expected to substantially increase both the volume and precision of information available for each individual, thereby, mitigating the current limitations and expanding the analytical potential of the collection.

Research lines

CNOC holds substantial research potential across multiple domains. Several avenues are already being pursued within a formally structured research program (currently under institutional ethics review), and a number of these lines are being developed through undergraduate and doctoral theses. Priority is given to the development and validation of methods for sex and age-at-death estimation, given the opportunity afforded by reliable antemortem documentation to evaluate the accuracy and precision of morphological and metric techniques developed in other contexts.

For adult sex estimation, analyses will encompass a comprehensive array of methods. Classical approaches will include the assessment of qualitative pelvic and cranial traits [30,81,82], as well as metrics of femoral and humeral head diameters [83,84]. This will be complemented by alternative approaches, including minimum supero-inferior femoral neck diameter [28,85,86], multivariate coxal metrics [87-89], odontometrics [90-92] and quantitative analysis of postcranial elements [93-96, among many others]. The concurrent availability of multiple skeletal and dental indicators will additionally allow the accuracy gains achieved through multivariate approaches that combine independent indicators to be evaluated against reliance on any single method.

For adult age-at-death estimation, traditional methods will include pubic symphyseal morphology [34,36], auricular surface metamorphosis [97], and cranial suture closure [39]. Complementary approaches will comprise changes of the articular surfaces of the first rib [98-100], pulp-chamber size [101], and root dentin translucency length using the Forensic International Dental Database (FIDB) methodology[2] [70-72,102]. In addition, recently developed multivariate probabilistic techniques, such as DRNNAGE [103] and Transition Analysis 3 [69,104], will also be validated.

A special focus concerns non-adult individuals, a subsample that remains small but whose expansion is prioritized in future field seasons. Sex estimation, one of the least resolved methodological challenges in biological anthropology, will be approached through evaluation of iliac and mandibular variables [105-108]. Dental dimorphism will also be assessed in both permanent (following the adult protocols described above) and deciduous dentition [109-110]. In addition, age-at-death estimation will draw on dental development [111,112], long-bone diaphyseal length [113,114], and metric analysis of elements such as pars basilaris and lateralis of the occipital bone [115-117].

Beyond biological-profile estimation, the medium- and long-term research agenda encompasses a diverse range of additional lines of research. Palaeopathological investigations will examine the skeletal manifestations of infectious diseases and other conditions recorded in death certificates, systematically comparing documented clinical information with observed osseous expressions [118-120]. Collaborations with specialist teams in ancient DNA and palaeogenomics are planned to contribute molecular data on pathogen identification and biological ancestry [121]. Dental-anthropological analyses will address oral health [122,123] and biodistance based on dental discrete traits [124-126], complemented by micro-computed tomographic reconstructions to explore relationships between internal dental structure and documented sex and ancestry [127-129]. The documented kinship network will also enable investigations of familial resemblance in morphological and pathological traits, and taphonomic research will focus on factors governing differential preservation [130]. Finally, digital resources will be developed,

[2]See https://iisap.odontologia.uba.ar/obs-bioarqueologia/.

including three-dimensional scanning of selected elements for incorporation into repositories that facilitate remote access to the collection [19].

CONCLUSIONS

CNOC represents a valuable addition to the identified skeletal series in Argentina. Comprising 65 individuals of both sexes, and supported by reliable documentation including demographic data, causes of death, and, in several instances, kinship relations, this collection joins the growing number of local population reference series developed in the country over the past decade. This initial characterization reveals a sample with a balanced sex distribution, a substantial proportion of older adults and a compositional profile reflecting the demographic consequences of the immigration processes that shaped the Pampean region between the late nineteenth and early twentieth centuries. The identification of documented familial relationships among several individuals is an exceptionally valuable feature, offering novel research possibilities. Equally critical to the collection's scientific value is the rigorous methodological protocol employed for exhumation, processing, and management, which ensures sample integrity and preservation as well as the traceability of all procedures. Moreover, it is worth underscoring the particular attention devoted to bioethical considerations -including the dual-database system that safeguards the confidentiality of personal information and the adoption of respectful-handling principles-, fully consistent with current international standards.

The collection provides not only an adequate reference framework for the development and validation of sex and age-at-death estimation methods, but also facilitates research on morphological variability, palaeopathology, activity markers, taphonomic processes, and studies of familial resemblance. Its chronological and geographic complementarity with the archaeological sample from Cementerio Sud and Lobos Collection enables investigations of secular change and regional variability that a single collection typically cannot support. Finally, in a global context where the need for documented collections is widely recognized in bioanthropological research [1,5], and the ethical dimensions of human remains management are aspects of growing significance [74,75], this series stands as a solid, well-contextualized reference resource. Such engagement is particularly significant in towns such as SAG, where community-based research with local residents (many from families

with long-standing ties to the area) lends the work both a biological and a historical dimension, contributing to the recovery of social identity. Bioarchaeological and forensic research thus helps reconstruct local histories, including places and processes overlooked by conventional historical narratives.

Competing Interest Information

The authors have no competing interests to declare that are relevant to the content of this article.

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Tables

Decade	Births (n; %)			Deaths (n; %)		
	Females	Males	Total	Females	Males	Total
1840-1849	3; 4.62	4; 6.15	7; 10.77	0; 0.00	0; 0.00	0; 0.00
1850-1859	3; 4.62	0; 0.00	3; 4.62	0; 0.00	0; 0.00	0; 0.00
1860-1869	3; 4.62	3; 4.62	6; 9.23	0; 0.00	0; 0.00	0; 0.00
1870-1879	3; 4.62	5; 7.69	8; 12.31	0; 0.00	0; 0.00	0; 0.00
1880-1889	6; 9.23	2; 3.08	8; 12.31	0; 0.00	0; 0.00	0; 0.00
1890-1899	5; 7.69	4; 6.15	9; 13.85	0; 0.00	0; 0.00	0; 0.00
1900-1909	6; 9.23	4; 6.15	10; 15.38	1; 1.54	1; 1.54	2; 3.08
1910-1919	0; 0.00	9; 13.85	9; 13.85	0; 0.00	9; 13.85	9; 13.85
1920-1929	1; 1.54	0; 0.00	1; 1.54	5; 7.69	2; 3.08	7; 10.77
1930-1939	1; 1.54	0; 0.00	1; 1.54	7; 10.77	6; 9.23	13; 20.00
1940-1949	0; 0.00	1; 1.54	1; 1.54	1; 1.54	5; 7.69	6; 9.23
1950-1959	1; 1.54	0; 0.00	1; 1.54	7; 10.77	6; 9.23	13; 20.00
1960-1969	0; 0.00	0; 0.00	0; 0.00	5; 7.69	3; 4.62	8; 12.31
1970-1979	0; 0.00	0; 0.00	0; 0.00	2; 3.08	1; 1.54	3; 4.62
1980-1989	0; 0.00	1; 1.54	1; 1.54	3; 4.62	0; 0.00	3; 4.62
1990-1999	0; 0.00	0; 0.00	0; 0.00	1; 1.54	0; 0.00	1; 1.54
Total	32; 49.23	33; 50.77	65; 100	32; 49.23	33; 50.77	65; 100

Table 1. Distribution of individuals by decade of birth and decade of death.

Sex	n	Mean (years)	SD	Minimum (days)	Maximum (years)	25^{th} perc.	50^{th} perc.	75^{th} perc.
Female	32	57.72	21.98	42	90	52.25	63.50	74.25
Male	33	53.42	26.41	1	87	37.00	51.00	72.00
Total	65	55.54	24.32	1	90	43.00	62.00	72.00

Table 2. Descriptive statistics of age-at-death, by sex.

Age-at-death cohort (years)	Females (n; %)	Males (n; %)	Total (n; %)
0-9	1; 1.54	1; 1.54	2; 3.08
10-19	0; 0.00	0; 0.00	0; 0.00
20-29	5; 7.69	6; 9.23	11; 16.92
30-39	0; 0.00	1; 1.54	1; 1.54
40-49	0; 0.00	5; 7.69	5; 7.69
50-59	5; 7.69	5; 7.69	10; 15.38
60-69	12; 18.46	4; 6.15	16; 24.61
70-79	7; 10.77	5; 7.69	12; 18.46
80-89	1; 1.54	6; 9.23	7; 10.77
90-99	1; 1.54	0; 0.00	1; 1.54
Total	32; 49.23	33; 50.77	65; 100

Table 3. Distribution of individuals by age-at-death cohort and sex.

Cause-of-death	Females (n; %)	Males (n; %)	Total (n; %)
Diseases of the circulatory system	5; 10.64	7; 14.90	12; 25.54
Neoplasms	6; 12.77	6; 12.77	12; 25.54
Diseases of the respiratory system	1; 2.13	5; 10.64	6; 12.77
Infectious diseases	2; 4.26	2; 4.26	4; 8.52
Diseases of the digestive system	2; 4.26	1; 2.13	3; 6.39
Diseases of the central nervous system	2; 4.26	2; 4.26	4; 8.52
Diseases of the urinary system	0; 0.00	1; 2.13	1; 2.13
Trauma	2; 4.26	0; 0.00	2; 4.26
Other	2; 4.26	1; 2.13	3; 6.39
Total	22; 46.81	25; 53.19	47; 100

Table 4. Distribution of documented causes of death, by sex.

Figures

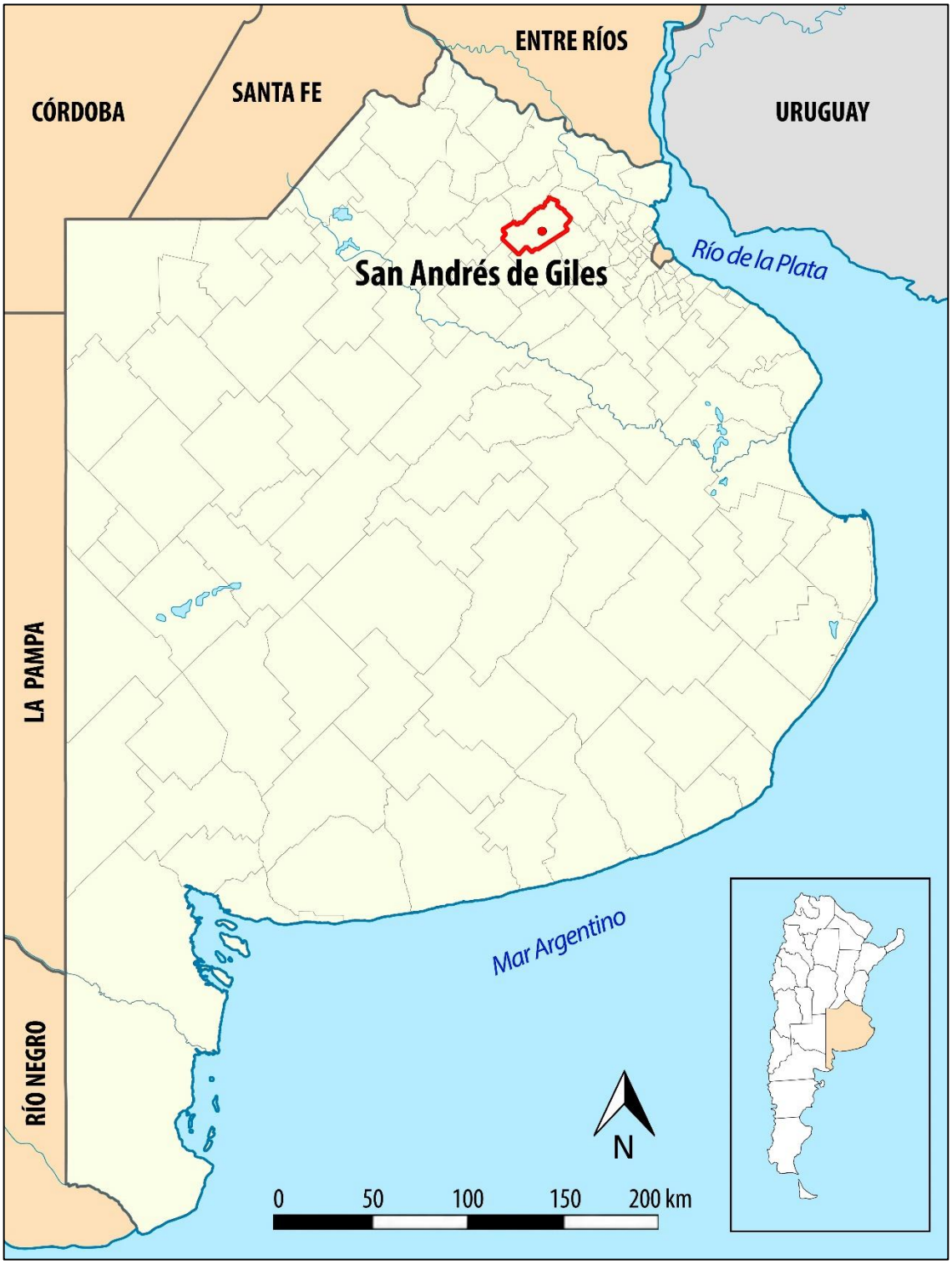


Fig 1 SAG location within Buenos Aires Province

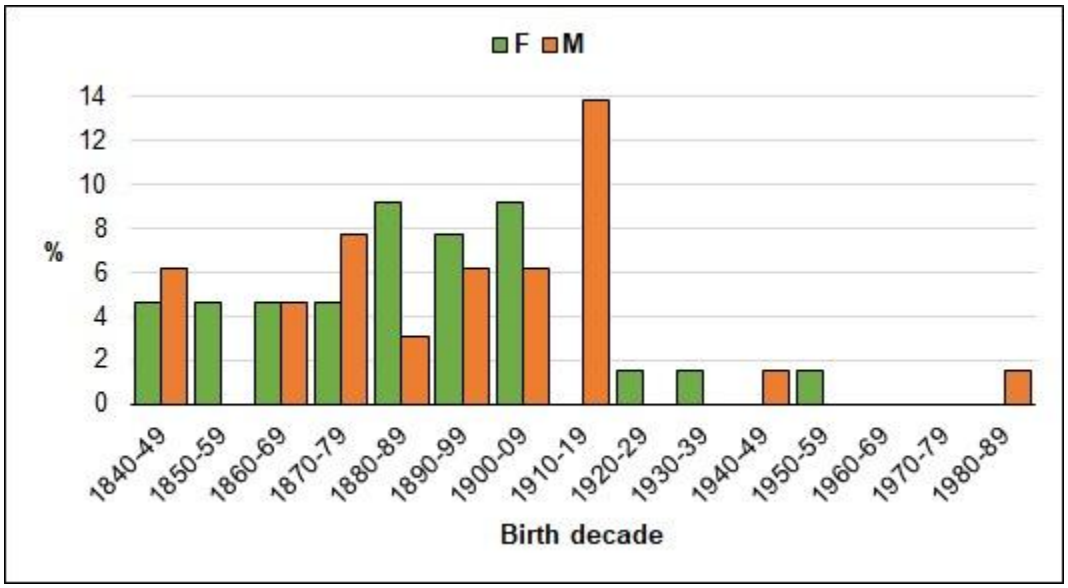


Fig 2 Distribution of individuals by decade of birth and sex

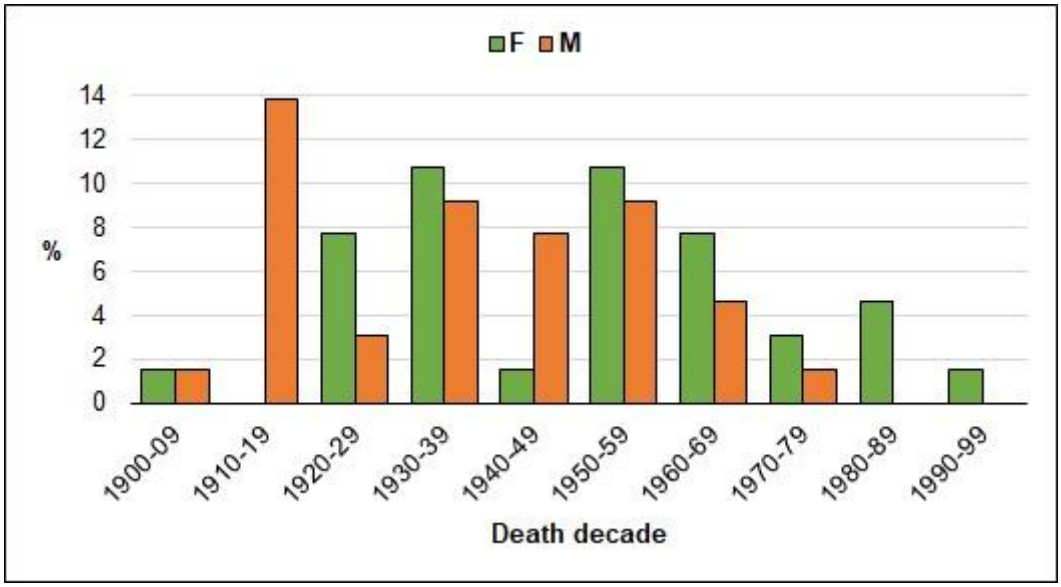


Fig 3 Distribution of individuals by decade of death and sex

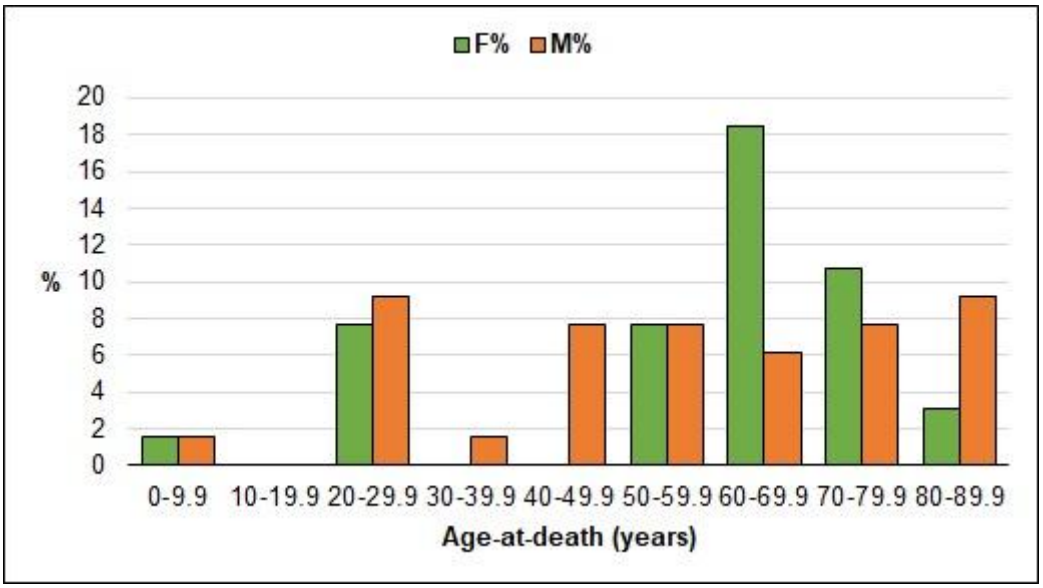


Fig 4 Age-at-death distribution, by sex

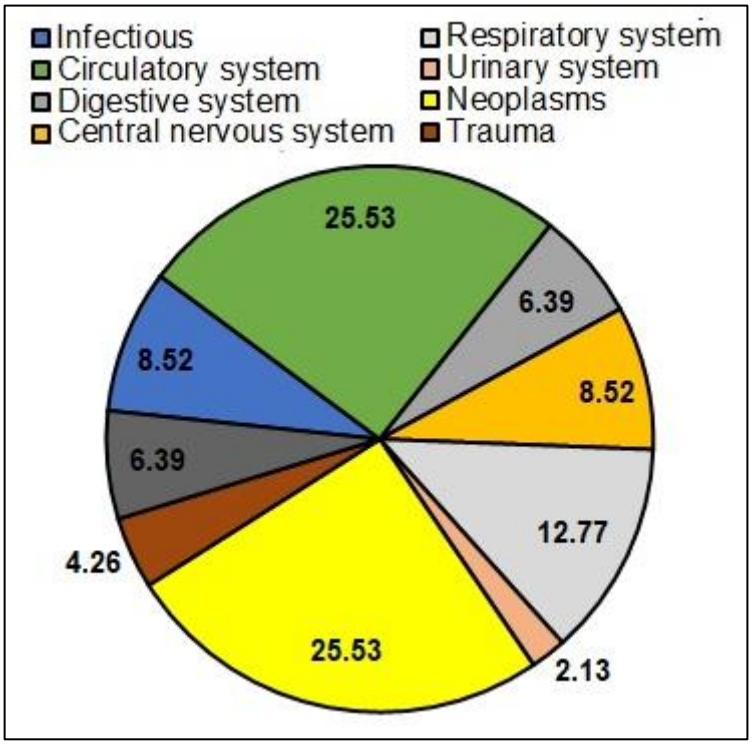


Fig 5 Frequencies of causes-of-death (n=47)