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ADULT MORTALITY ESTIMATE BASED ON
INFORMATION ON AGE STRUCTURE OF
DEATHS. AN APPLICATION TO DATA FOR
SAN FELIPE AROUND 1787

13919

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SUMMARY

A method to estimate adult mortality on the basis of information on age structure of annual deaths and population, is presented. The basic relation is valid, strictly, in a demographic model called 'stable population'. However, the robustness of the main relation permits its extension to actual populations.

The application was made to information available from parochial deaths registers of San-Felipe and population censuses taken in the area in 1787.

The resulting estimates of mortality in terms of a life table for the age interval 10-60, are compared with existing estimates for periods covering approximately, from mid XVIII century to mid XIX century, which correspond to mortality estimates for Chilean religious groups and to the population of a parish close to Santiago, Nuñoa. The estimate for San Felipe is higher than the mortality of these two populations.

RESUMEN

Se presenta en este documento una aplicación de un método para estimar la mortalidad adulta a partir de información sobre las estructuras por edad de las muertes y de la población. La relación fundamental en que se apoya es válida, en rigor, sólo en un modelo demográfico llamado 'población estable'. Sin embargo la solidez de la relación permite extender su aplicación a poblaciones reales.

Se utilizaron datos disponibles de registros parroquiales de defunciones de la Parroquia de San Felipe y de censos de población levantados en esa área en 1787.

La estimación resultante de la mortalidad, expresada en una tabla de vida para el tramo de edades 10 a 60 años, se compara con estimaciones existentes para un período que cubre aproximadamente desde mediados del siglo XVIII hasta mediados del siglo XIX y que corresponden a la mortalidad de monjes chilenos y a la de una población de una parroquia cercana a Santiago, Nuñoa. El nivel estimado de mortalidad para San Felipe es superior al de estas dos poblaciones.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions.

2. It then goes on to describe the various methods used to collect and analyze data.

3. The next section details the results of the study, showing a clear trend towards higher productivity.

4. Finally, the document concludes with a series of recommendations for future research and implementation.

5. The overall findings suggest that the proposed system is highly effective and should be widely adopted.

6. This report provides a comprehensive overview of the project's progress and the challenges encountered.

7. The data collected over the past six months has been carefully reviewed and analyzed.

8. The results indicate that there has been a significant improvement in the efficiency of the process.

9. It is important to note that these findings are based on a limited sample size and further research is needed.

10. The next phase of the project will focus on scaling up the system to a larger number of users.

11. We believe that the current results are a strong indicator of the system's potential.

12. The team is committed to ensuring that the system meets the highest standards of quality and reliability.

13. We look forward to continuing our collaboration and sharing our findings with the wider community.

14. The project has been a great learning experience and we are grateful for the support and feedback provided.

15. We hope that this report provides valuable insights into the challenges and solutions of this project.

16. The team is excited about the future and the potential for further innovation and growth.

17. We are confident that the system will continue to evolve and improve over time.

18. Thank you for your attention and interest in this project.

19. We are happy to answer any questions you may have.

20. We look forward to staying in touch and sharing our progress as we move forward.

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QUESTION

1. The following table shows the number of people who attended a concert in each of the five years from 2000 to 2004. The number of people who attended the concert in each year is given by the function $f(x)$, where x is the number of years since 2000.

Year	Number of people
2000	100
2001	150
2002	200
2003	250
2004	300

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ANSWER

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I. INTRODUCTION

This paper presents an application of a method for estimating adult mortality starting from information on age structure of deaths.

The study is based on data drawn from registers of deaths from the parish of San Felipe and on population censuses taken in that area in 1787.

The method, recently exposed by Professor Brass, (1) is particularly adequate to be used in Historical Demography. Successful applications have been made to reasonably good information on the number and age structure of deaths of small European localities, whose population sizes, however, were unknown. The method was precisely created to be used in cases for which information was only partially available. It might happen, for example, that deaths would correspond to only part of a population, and the age structure of the population, to another one.

The fundamental relation on which it is based is valid, strictly, for a demographic model denominated 'stable population'. Notwithstanding, the robustness of the relation, permits the extension of its application to actual populations.

Chapter II of this paper deals with the historical background of the population under study, the period under consideration, the parish registers and the 1787 censuses.

Chapter III describes the method and illustrates its application to the data available for San Felipe. Finally, in chapter IV the main conclusions are presented.

II. THE VILLAGE UNDER STUDY AND DOCUMENTARY SOURCES

a) Foundation of the village of San Felipe el Real

The city of San Felipe is located at 32° 45' latitude and 70° 44' longitude, inserted in the highest portion of the Aconcagua Valley and at the North bank and middle course of the Aconcagua river.

The Valley of Aconcagua seems to have been abundantly populated when the conquerors first travelled through it during the territorial inspections.⁽²⁾ Its proximity to the valley of the Mapocho river, where Santiago was founded, did not make it necessary the establishment of another city in Aconcagua; thus, it first remained under the jurisdiction of the Capital and later as a district (partido or corregimiento), subdivided into several units. The allotment of the indigenous lands and of the native population -granted as mercies to the conquerors in the sixteenth century- took place very early in the above mentioned valley.

However, during the same century the neighbouring "partido" of Quillota, which lied in the lower section of the valley, was indeed economically and administratively a much more important focus than San Felipe. Its nearness to the harbours of Valparaíso, Concón, Papudo and Quintero, the early exploitation of gold washings -especially in the creek of Longotoma-, the prompt adaptation of hemp culture, cereals and multiple livestock, permitted Quillota to be earlier defined as a peculiar economic space.⁽³⁾

In the dominium of Chile there was no clear distinction of economic regions until mid Eighteenth Century. This lasted until the total population became stabilized -or at least did not decrease- at the same time that the Central Valley started to adopt characteristics of a cereal growing and cattle raising agriculture and the inhabited portion of the Northpart of the country was specifically dedicated to the copper and silver mining. Together with the economic and regional specialization of the colony the normalization of commercial currents of imports and exports occurred. A continental route traversing Cuyo and reaching Paraguay and a maritime one, which connected the agrarian-miner production of Chile with the Peruvian and Alto-Peruvian markets, was then efficiently activated.

Within such complex the Aconcagua Valley occupied an exceptional situation; towards the South, it headed the agrarian frontier and to the North the mining horizon. Even if the named valley, because of the exploitations it developed, should be defined as agrarian, as early as the Eighteenth Century the district of Aconcagua developed a fairly active copper and silver mining.⁽⁴⁾ The lower portion of the valley -Quillota- became, because of its produces and circulation routes, the obliged outlet for exports to Peru. The middle and mountainous portion of the valley, that is to say, the district of Aconcagua was, on the other hand, the door for the Transandean commerce.

When the Spanish authorities noticed this situation, there was not a city in the district of Aconcagua to centralize the administrative functions required by the jurisdiction or that, at the same time, would have offered the possibility of concentrating the mestizo population which, with no lands or dwellings, was starting to loiter about in the valley.

In the year 1621, when the Tasa de Esquilache -a code setting up rules for the indigenous labour force- was announced, the district of Aconcagua had two Indian towns: Curimón and Apalta. The most important one was Curimón which acted as head of district. Jesuits established a school there and managed a rich land estate. Some 30 years later we find the same towns mentioned in the sources, except for the addition of the town of Putaendo which seems to have been populated by mestizos and Indians who came from other regions.⁽⁵⁾

Towards the end of the Seventeenth Century these Indian towns had almost no inhabitants with ancestors belonging to the place. Very few Indians lived there now, and as it was said at the time, these towns were "swarmed with mestizos". The "encomenderos", landholders and entrepreneurs had assigned the Indians to the "latifundios" of Aconcagua, Quillota and Santiago and also to the mining settlements of Norte Chico. Here they got mixed with immigrant Indians, "conchabados" and "cautivos" which had been transferred from the frontier of Arauco, also, with negroes and mulattoes. At the end of the Seventeenth Century, one of the most relevant "encomiendas" that still remained, was the one of Aconcagua. Its Indians were assigned in "encomienda" in 1694, to doña Catalina Chacón y Carvajal who transferred them to Codao in the district ("partido") of Rancagua.

Along the Eighteenth Century the indigenous population declined steadily, particularly the group of "indios de encomienda". In 1744 the whole district of Rancagua held only 4 "encomiendas" which scarcely gathered 28 adult Indians. In 1759 the amount was exactly the same; in the year 1770, perhaps because the enumeration was more carefully done or because it included Indian families which lived in distant landed properties, or because it comprised the "outsider" Indians, the same four "encomiendas" totalized 192 tributary Indians. (6)

At the beginning of the Eighteenth Century and previous to the enforcement of the population policy which will be referred to below, the rural panorama of Chile was very distinctive. In addition to the traditional cities there were only a handful of semi-abandoned Indian towns. Within the landholdings of the Central Valley, one could find groups of peasant houses, which very seldomly reached the status of towns. Only a few mining settlements and working centres had been able to generate "spontaneous" agglomerations of dwellings.

On the other hand, the traditional "latifundio", that was still in its infancy during those years, far from making a profitable use of labour force and agrarian resources, was completely unable to withhold the free Indian and mestizo population. Thus, a floating population of great magnitude arose called by the Spaniards "vagabundos" (vagrants) which by turn passed their lives in the seasonal agricultural work, the mining labour or in brigandage and cattle robbery. (7) The district of Aconcagua was particularly affected by this phenomenon, provided that the intermitent existence of copper and silver mines in Norte Chico and in Aconcagua itself, pulled strongly such floating population on the one hand, and on the other, the periodical exhaustion of mining labour left hundreds of miners at the doors of vagrancy. The amount of despoilment they made in the landholdings of Aconcagua called for the establishment of a militar garrison in the Indian town of the same name, before the foundation of San Felipe when the latter had almost no Indians. (8)

The Crown, taking into consideration these circumstances, commanded through a Royal Decree in 1703, that the Spaniards should gather themselves

to live in cities mainly in those that already existed, and if necessary, villages should be created in order to concentrate the scattered population.

Following this Command, only one village was established, Quillota in 1717, but the occasion was given for the establishment of the Population Council (Junta de Poblaciones). This Council was constituted with representatives from the bishoprics, city councils, Real Audiencia, government, etc. and it effectively started tracing a population policy.

Taking this background into account, Governor José Manso de Velasco initiated a series of foundations. By mid 1740 he travelled through the district of Aconcagua and gathered the opinion of the 34 landholders who owned the agricultural area of the place. At a meeting held in the San Francisco Convent -located in the Valley of Santa Rosa where the city of Los Andes was later founded- the establishment of the village of San Felipe el Real was decided at the exact point where it lies today. The selection of the spot for setting up the city seems to have been determined by the presence of a nearby convent from the Order of Mercedarios and by the offering from Andrés de Toro Hidalgo of a square piece of land having 49 blocks by side, plus the shoals and lowlands close to the river. The foundation was decreed on the 4th of August of the aforementioned year. A plan of the city was immediately elaborated containing rules and regulations that carefully prescribed the settlement process. The buildings, however, did not start until several months later. (9)

b) Population and documentary sources

The population growth of San Felipe took place very slowly. Ten years after its foundation it only amounted to a hundred settled families, which meant around 600 inhabitants. In 1787 there were 491 families which totalized a little more than 2 000 inhabitants. When the first republican census was taken in 1813, the number of families and inhabitants still remained the same. (10)

The population growth of San Felipe seems to have stopped particularly because of two facts. Until the year 1790 the circulation of passengers and

muleteers from Santiago to Cuyo, way to Buenos Aires, Córdoba, Montevideo and Asunción, worked through San Felipe. In that year, however, the hanging bridge was built over the Aconcagua river in Las Vizcachas and in the following year, the village of Santa Rosa de Los Andes was founded, all of which caused the flow of commerce and passengers -together with the material equipment it implied- to be transferred from San Felipe to Los Andes. A compensation to this situation only appeared around 1823 when the route that linked directly the mountainous portion of the Aconcagua valley to Valparaíso through San Felipe was built. This rebounded immediately on the population and from the economic point of view it brought about a fall in prices of agricultural exports, due to the lower cost of transportations. (11)

Another fact which explains the slow growth of the city is the territorial and economic weakness of large landings in the Valley, that were symptomatically hiring "medieros" and "inquilinos". At the same time a considerable number of small landholders and small field labourers appeared who settled in the surroundings and in shoals and corners of the village. In this manner an important amount of inhabitants of the district attached themselves to the country, without increasing the urban population of San Felipe. (12) As it will be seen, this peculiar situation determined some of the methodological characteristics of our handling of data.

In the region, the ecclesiastical organization appeared as early as the administrative one, and sometimes even previously. In the practice, in the Spanish colonies, these two administrations complement each other, and many of the times they get mixed up. Before the Intendent Office as an administrative civil unit was created, the territory of the colony was divided into bishoprics, and these, in their turn, into "corregimientos". The "corregimientos", as far as religious administration is concerned, fragmentized into "doctrinas", as they were called by the natives of the rural areas. Each "doctrina", in principle, had to comprise a parish, though in the practice, this did not occur. In this way, many "doctrineros" (priests) had to keep registers of baptisms, marriages and deaths in parishes that did not belong to their "doctrinas".

The Aconcagua territory in 1585 comprised the "doctrinas" of Aconcagua Curimón and Putaendo, of which only Curimón had a parish. Registries of

the Aconcagua sub-division stopped operating during the Seventeenth Century, so baptisms, marriages and deaths occurring in San Felipe were registered in Curimón and Putaendo. Circumstances changed since 1729 when Curimón opened special records for the district of Aconcagua. The archives were transferred to San Felipe when the village was founded. It is important to point out that since parishes did not exist regularly and since the place and boundaries of "doctrinas" and parishes were often unknown to the peasants of the region, people used to inscribe births and deaths in any of the parishes handling records. This fact makes it hard to carry out a research utilizing registers of those years. (13)

Annotations of deaths in the parish of Curimón start in 1677 and in San Felipe, in 1729. For some years the corresponding books remain lost. These registers contain the same shortcomings, common to all statistical series of deaths in Latin America. They have not been carefully kept; therefore, there exists a generalized under-registration phenomenon; dates of deaths or ages at death are very unreliable. One of the most important reasons for this deficiency is that annotations were made weeks or even months after the event had taken place.

For research purposes we needed a series of six to eight years in which death annotations were as complete and reliable as possible and at the same time, that for one of the years selected there existed some kind of population enumeration or census containing the population distributed by age. This demanded us to cover the year 1787; we could then count on two enumerations for San Felipe.

Data for deaths by age were drawn from Defunction Books from the San Felipe parish, from 1780 to 1787. To detect anomalies and to achieve effective comparisons, we simultaneously took note of deaths occurred in the neighbouring parishes of Quillota and Petorca. (14) We also examined baptisms and marriages so we could, on the one hand, check migration and on the other, individualize by name, birth and death dates, a high percentage of people. This information was later used to confirm and correct ages of individuals enumerated in the 1787 census.

In this way, we were able to detect two anomalies which later lead us not to take into account in our research the years from 1780 through 1782.

Between the years 1779 and 1780 the colony was affected by an epidemic that was particularly malignant in the Norte Chico. It increased the number of deaths four times in 1779 and six times the following year. Besides, in 1782 the books seem to have been kept with exceptional carelessness, therefore we preferred to treat such year as if there were no data available.

In 1787 two censuses were taken in the village. The one that is best known, called "Padrón Civil de San Felipe" contains surname and name of each couple, number and sex of children, plus identification of relatives, adherents, servants and slaves that dwelled in every residence. They do not include the age of each individual regularly. The other census known as "Padrón Religioso de San Felipe", furnishes very similar data, except for the fact that it is particularly thorough in relation to the ages 0 to 10 years. Having the individualization of practically every inhabitant of the village in that year, it was possible to fill in the missing ages with sources as Informaciones Matrimoniales, judicial and notarial documents etc. (15)

The research was made computing the white mestizo population exclusively, named at that time with different terms, namely: Spaniards, American Spaniards, whites, mestizos, etc. Expressions such as Indians, coloured mestizos, zambos, mulattoes, coloured breeds, etc. were used for that portion of society that was ostensibly Indian or mestizo or African descendant.

We have already described how rapidly the indigenous population declined to such a point in which parsons stopped recording sacraments in special books for Indians, and started to note them up in the ones that belonged to whites or criollos, remarking their ethnics, when it was evident, at the margin of the register. Thus, surely a small percentage of our aggregate -impossible to determine- had an indian parent. Black stock was more difficult to hide or confuse and it was registered in special records exclusively devoted to colour breeds; in our results, it appears insignificant. We think that the figures we handle for whites in our research reach 60 percent of the total population of the village. From the point of view of the socioeconomic status of whites, we can say that they shared every social order of the rural areas of the period. They are all countrymen, from big landowners and small proprietors, "medieros", "inquilinos", to "gañanes" and common peons.

After we accomplished this stage of our research we found ourselves faced to another hindrance. It was most noticeable when we were gathering the information, though it only could be evaluated during the data processing. No normal correlation of magnitude existed between the enumerated population and the amount of deaths registered in the parish. The latter were clearly higher than what corresponded to the amount of inhabitants in 1787. The problem was that the census lists utilized, exclusively covered inhabitants from the village of San Felipe, while the parochial records embraced a much greater populated area. When reviewing general descriptive sources of the region, we had noticed that a relatively important amount of "inquilinos" and small landholders did not have a fixed residence in the city so they were not included in the lists. In this connection, Thaddeus Peregrinus Haenke, a traveller that thoroughly visited the place in 1794, had observed: "Its capital city is San Felipe el Real, a short population, poor in buildings, because of reasons identical to those militating throughout the Colony for the scarce neighbourhood of population; because of living in the country and being subdued to their landholding enclosures, from which they traffic and give way out to their produces, most of people do not contribute as they should to the fomentation of the capital cities".⁽¹⁶⁾

The way in which this problem was faced to in our study is described in the following chapter. We would like to end up with a description of the kind of aggregate whose mortality is being studied. It is a white rural country population, little affected by migration, that could easily be typical of the Central Valley of Chile in the last decades of the Eighteenth Century.

III. DESCRIPTION AND APPLICATION OF THE METHOD

a) Description

The method is based on a relation that is valid on a demographic model called "stable population". It is not our purpose to give here a detailed description of that model, which would be out of place, but only to point out its essential characteristics. Given a law of mortality, i.e., a life table, and a law of fertility, i.e., a set of annual fertility rates by age, which are assumed to be constant in time, a stable population is defined. The model also assumes that the population is not affected by migrations, i.e., it is a closed population. In such circumstances the population changes with a constant rate of increase (or decrease) and necessary relations exist, also constant, between different demographic characteristics such as, the age structure, the birth and death rates, etc.

William Brass derived one of the necessary relations in a stable population, in which the method that is being analysed is based:

$$N(x)/N(x+) = r + D(x+)/N(x+)$$

in which:

$N(x)$: represents the density of people at the exact age x in the population,

$N(x+)$: represents the number of people aged over x in the population,

r : represents the annual rate of increase, constant,

$D(x+)$: represents the number of deaths aged over x in the population.

In a stable population this relation holds in all cases. If the values $N(x)/N(x+)$ are represented in the ordinates, and $D(x+)/N(x+)$ in the abscissae, the points obtained, one for each value of x , define a straight line, with slope equal to 1.

In a real population, in which the conditions that define the stable population are not given (since it is open to migrations and since mortality

and fertility change in time) and in which, moreover, data representing it are affected by errors (omissions, misstatements of age) we can expect, however, that observed points, similar to the theoretical ones suggest also a linear trend. When this occurs, Brass proposes to adjust a straight line to the observed points and, from it, assuming that the valid relations in a stable population hold, to derive then some characteristics on mortality or on the natural increase of the population considered, for the adult age intervals.

The method is unsuitable to be applied to data concerning early ages in life although theoretically, in the stable population, the established relation is valid at any age, including the first ones. It frequently happens that data available for early ages are affected by errors of different magnitude and sometimes, of a different sense than those concerning adult ages and, furthermore the incidence of mortality in early childhood is more difficult to measure.

In the illustration that follows the method is applied starting from age 10. Besides, because of the apparent exaggeration in the registered deaths for ages over 60, the analysis is limited to the age interval up to this age. In other words, as it will be shown below, the study of mortality is restricted to the 10-60 age interval.

b) Data

The application of the method proposed by Brass is illustrated with data from death registers of a parish in San Felipe and from two censuses taken in 1787 that were compounded into one. The series of annual deaths, between 1780 and 1787, presents some awkward features, some of them due to real changes in mortality at that time and others to errors in registration.

Thus, for example, in 1780, 145 deaths are registered while in 1781 only 45. The former corresponds to a year of epidemic the latter, probably as a consequence of the epidemic, shows a clearly lower mortality than the annual average. There is no information for 1782. From 1783 to 1787, which is the last year with information available, the annual figures of

deaths show only minor variations. Therefore, they can be considered as representative of normal years, if we consider as normal those in which there is no epidemic or in which there is not an extremely low mortality. We will use the information relative to the five years, from 1783 to 1787, for the analysis that follows.

The series of annual deaths, between 1780 and 1787, appears in Table 1. Table 2 presents the total deaths in the quinquennium 1783-1787, by age groups, and the mean annual values.

Table 1

TOTAL DEATHS REGISTERED BY YEAR. 1780-1787.

Year	Total deaths
1780	145
1781	45
1782	No information available
1783	78
1784	72
1785	68
1786	59
1787	85

Information on the population, classified by decennial age groups, for 1787, is shown in Table 2 and represented in Figure 1. Examining the information contained in the table and the figure it can be concluded that, in spite of some errors in the age structure, the information seems to be quite reasonable for an increasing population. The age composition does not reflect the effects that frequently appear when a population is affected by migratory movements.

Figure 1

POPULATION AGED BELOW 60 BY DECENNIAL AGE GROUPS

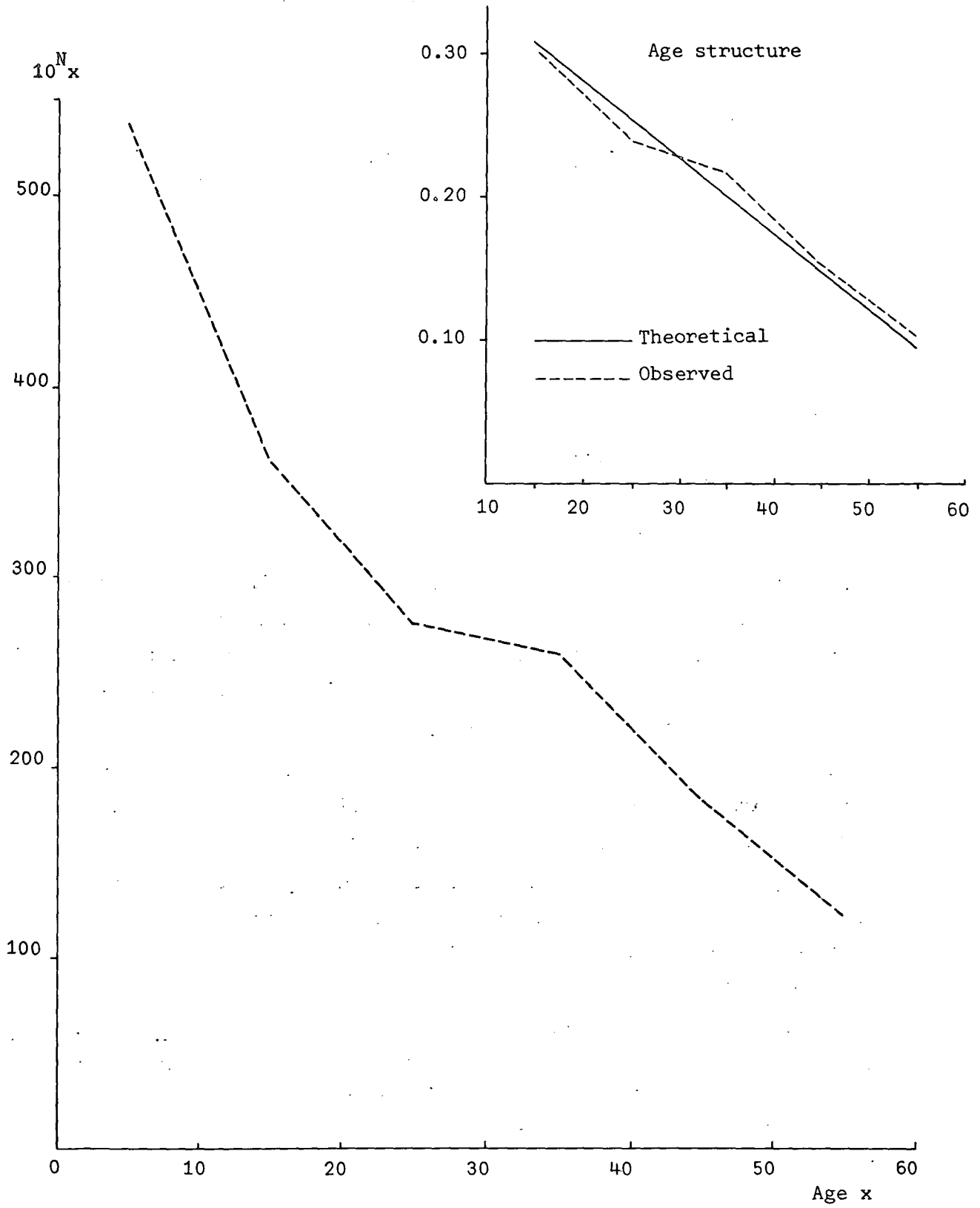


Table 2

SAN FELIPE. DEATHS REGISTERED IN THE QUINQUENNIUM 1783-1787,
ANNUAL MEAN NUMBER OF DEATHS AND POPULATION ENUMERATED IN
1787, BY AGE

Age groups	Registered deaths 1783-1787	Annual mean	Population enumerated 1787
0-9	54	10.8	539
10-19	32	6.4	363
20-29	70	14.0	277
30-39	36	7.2	260
40-49	35	7.0	184
50-59	49	9.8	124
60 and over	86	17.2	71
Total	362	72.4	1 818

c) The observed mortality

If we accept that the above data are comparable, i.e., that the annual deaths -an average of those registered between 1783 and 1787- correspond to the population, we can calculate the death rates in different age groups which constitute a measure of mortality. A life table, the usual instrument to express the mortality level in demography is, after all, a set of death rates by age.

That exercise is conducted in Table 3 for the age groups over 30. We can compare the results with other existing mortality estimates for the past in Chile and, therefore, get an idea about the plausibility of the results obtained.

Consequently, Table 3 presents death rates for age groups over 30, for San Felipe (1783-1787), and those that have been estimated for the XVIII and XIX centuries for a population of Chilean religious⁽¹⁷⁾ and for the 1866-1871 for a population in Nuñoa.⁽¹⁸⁾

The examination of the above results shows an excessively high mortality, more than double, in San Felipe than in the other two populations. Although it is possible, and it could be expected, that the direction of the difference, between the mortality levels in the populations compared, is as shown by the figures, its magnitude does not seem reasonable. We have the feeling

Table 3

COMPARISON OF DEATH RATES, BETWEEN 30-60, FOR SAN FELIPE (1783-1787)
FOR CHILEAN MONKS AND NUNS (XVIII AND XIX CENTURIES) AND FOR
A POPULATION IN NUÑO A (1866-1871)

Age groups	San Felipe 1783-1787	Chilean religious c. XVIII-c. XIX	Population in Nuño a 1866-1871
30-39	.0277	.0121	.0117
40-49	.0380	.0199	.0170
50-59	.0790	.0327	.0301

that the registered deaths do not correspond to the population enumerated but, instead, to a population of a larger area than San Felipe.

The Brass method permits to investigate such possibility, what is done in the following points.

d) Application of the Brass method

In Table 4 the analysis of the information, according to the above considered equation, is presented. The only term in the relation that requires a special comment is $N(x)$, the density of persons at exact age x , since the others, $N(x+)$ and $D(x+)$, are explained by themselves. They represent, respectively, the number of persons and deaths with ages over x .

The density of persons at the age x is calculated:

$$N(x) = 1/20 ({}_{10}N_{x-10} + {}_{10}N_x)$$

where ${}_{10}N_{x-10}$ and ${}_{10}N_x$ represent the number of persons in the population with ages $x-10$, $x-1$ and x , $x+9$, respectively.

The results, i.e., $N(x)/N(x+)$ and $D(x+)/N(x+)$, for $x = 10, 20, 30, 40$ and 50 are represented in Figure 2. The five points show a trend that can be described, approximately, by a straight line. The slope of the straight line describing the points, that has been drawn freehandly in the same figure (solid line) is not, however, the expected one.

Figure 2

COMPARISON OF AGE STRUCTURES OF DEATHS AND OF THE POPULATION

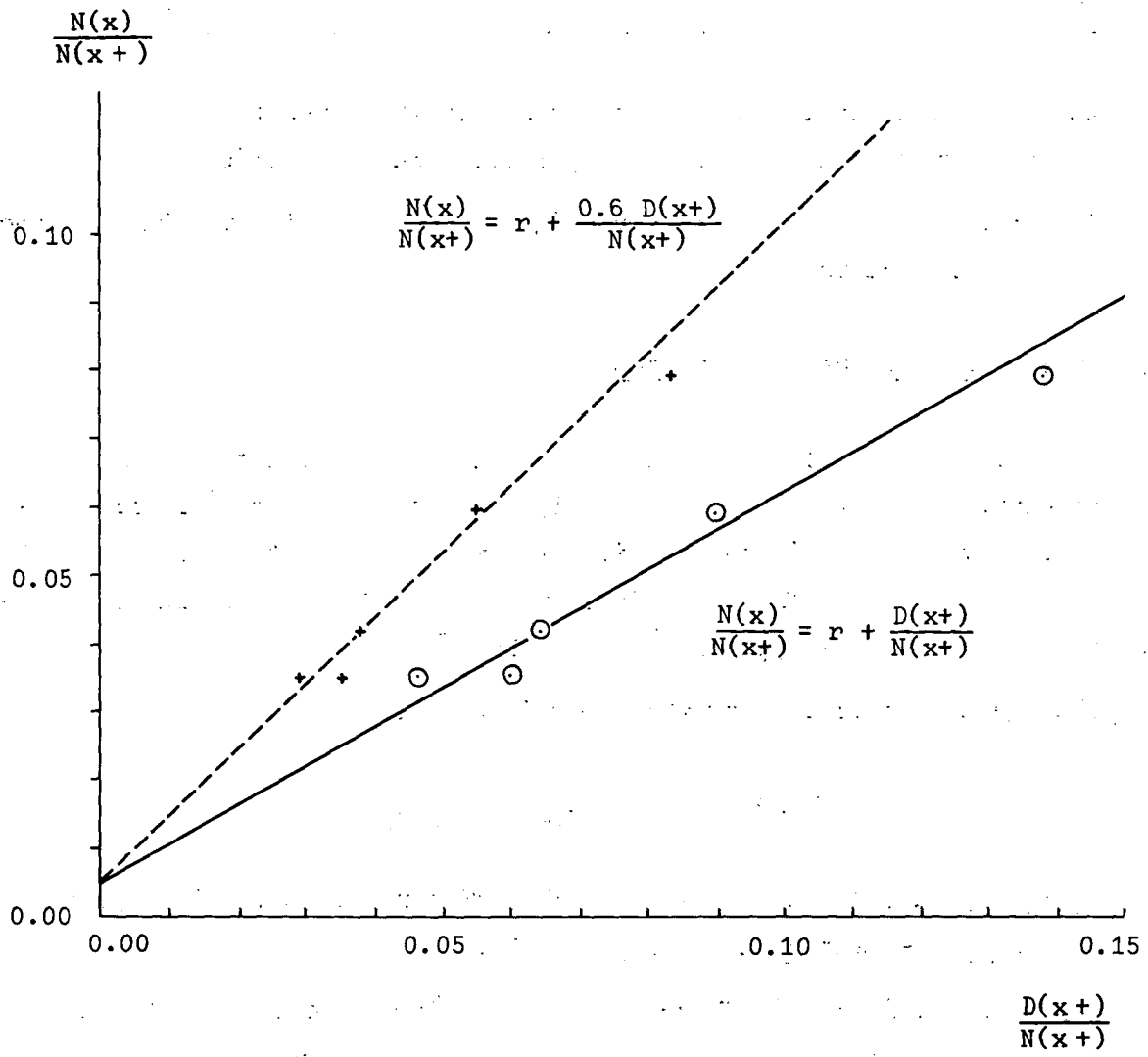


Table 4
SAN FELIPE. APPLICATION OF THE BRASS FORMULA

Age	Population aged x and over $N(x+)$	Annual deaths x and over $D(x+)$	Population density at age x $N(x)$	Ratio		
				$\frac{N(x)}{N(x+)}$	$\frac{D(x+)}{N(x+)}$	$\frac{0.6D(x+)}{N(x+)}$
0	1 818	72.4				
10	1 279	61.6	45.1	.035	.048	.029
20	916	55.2	32.0	.035	.060	.036
30	639	41.2	26.8	.042	.064	.038
40	379	34.0	22.2	.059	.090	.054
50	195	27.0	15.4	.079	.138	.083
60	71	17.2				

We have seen above that the slope of the straight line, in theory, should be 1. To obtain that value, with a straight line describing the observed points, it is necessary to take a fraction of the registered deaths. The fraction that sets the adjusted straight line with an acceptable slope is 0.6, i.e., only 60 percent of the registered deaths, in all ages over 10, seems to correspond to the population given by the 1787 census. The elaboration of the data and the results obtained appear also in Table 4 and in Figure 2 (broken line). The exercise has also permitted to establish an estimate, probably very rough, of the rate of increase of the population over 10: 5 per thousand per year. It is the point of the straight line that intersects the axis of the ordinates.

e) Estimate of mortality and of a theoretical age structure

It seems rather unnecessary to warn the reader that the estimates obtained, as well as those that are derived below, are very rough and, consequently, must be taken with caution. In spite of this limitation, it is interesting to establish what could have been the mortality level of the

population studied, according to the assumption that only 60 percent of the registered deaths corresponds to the population enumerated in San Felipe in 1787. Because of the limitations of the data the analysis starts at age 10 and stops at age 60, since the observed death rate, for ages over 60, is extremely high, even if it is calculated with only 60 percent of the registered deaths. It is surely a gross exaggeration of the real value.

The elaboration of the life table for the age interval 10-60 is presented in Table 5. Given the information on deaths by decennial age groups (60 percent of the registered ones) and the census information on the population by ages, death rates are calculated (10^m_x) and from them the probabilities of survival for decennial age intervals using, for this purpose, an approximate relation. From those probabilities, the values of the survival function are deduced (l_x), taking an arbitrary root at age 10. The values thus obtained are adjusted using a method suggested by Brass⁽¹⁹⁾ that resorts to a standard life table. The so-called logit function of ($1-l_x$) is used:

$$Y(x) = 1/2 \ln \frac{1-l_x}{l_x}$$

The life table is obtained by adjusting the observed values, $Y^o(x)$, by a linear relation on the standard values, $Y^s(x)$. To define the straight line two pairs of values are determined that result from averaging the three first and the three last points appearing in Table 5, respectively. The results are:

$$1Y^o = -.3039$$

$$2Y^o = -.3878$$

$$1Y^s = -.4400$$

$$2Y^s = -.0024$$

The following system of equations is obtained:

$$1Y^o = A + B \cdot 1Y^s$$

$$2Y^o = A + B \cdot 2Y^s$$

Table 5

SAN FELIPE. CONSTRUCTION OF A LIFE TABLE FROM CORRECTED NUMBER OF DEATHS, IN THE 10-60 AGE INTERVAL

Age	Corrected deaths	Population	Death rate	Probability of survival	Number of survivors	Logits of $(1-l_x)$	
						Observed	Standard
x	$0.6 \cdot 10^D_x$	10^N_x	10^m_x	10^p_x	l_x	$Y^O(x)$	$Y^S(x)$
10	3.84	363	.0106	.8996	.7502	-.5498	-.5498
20	8.40	277	.0303	.7384	.6749	-.3652	-.4551
30	4.32	260	.0166	.8469	.4983	.0033	-.3150
40	4.20	184	.0228	.7959	.4220	.1572	-.1817
50	5.88	124	.0474	.6224	.3359	.3408	-.0212
60					.2091	.6653	+.2100

- Notes: - The corrected deaths are 60 percent of the registered ones
 - The values of 10^p_x are calculated by the approximate relation:

$$10^p_x = e^{-10 \cdot 10^m_x}$$

- The values l_x are obtained: $l_{x+10} = l_x \cdot 10^p_x$ from an arbitrary root, $l_{10} = .7502$ (the same value as in the standard table).
 - The logits of $(1-l_x)$ are defined:

$$Y(x) = 1/2 \ln \frac{1-l_x}{l_x}$$

Therefrom the values of the constants A and B are defined: A=.3840 and B=1.5635. The expression of the adjusted life table, in terms of the logits of the function $(1-l_x)$ is, consequently, the following:

$$\bar{Y}(x) = .3840 + 1.5635 Y^S(x)$$

Using this relation, several life table functions were calculated which are presented in Table 6. The values appear for five year intervals, with the usual notation, between ages 10-60, which is the age interval studied.

Table 6
 SAN FELIPE 1783-1787. LIFE TABLES BETWEEN THE AGES 10-60

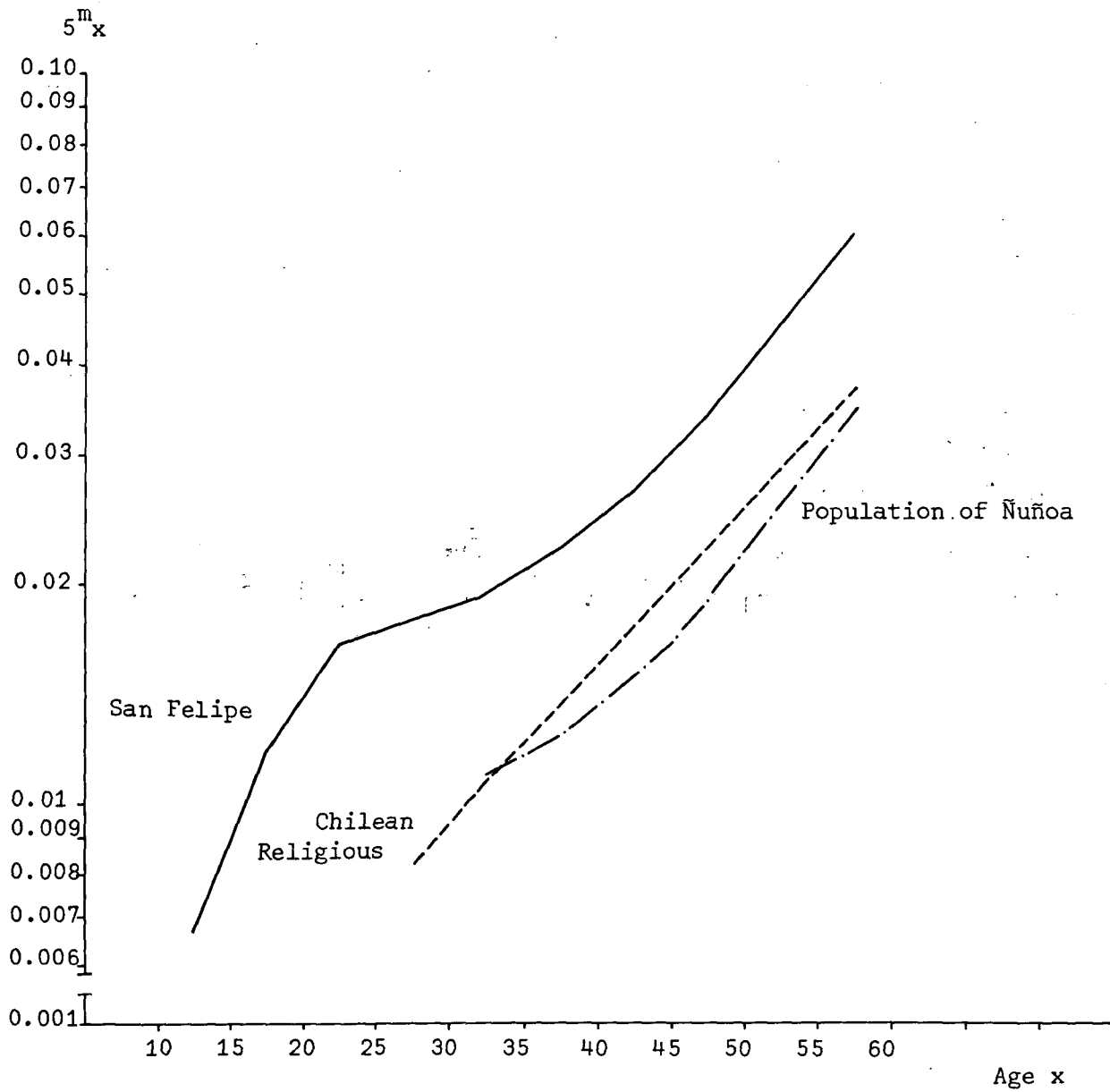
Age	Survivors	Time lived between x and $x+5$	Time lived between x and 60	Deaths	Mortality rate	Expectation of life between x and 60
x	l_x	$5L_x$	$60-xL_x$	$5d_x$	$5m_x$	$60-xe_x$
10	.7214	3.5478	24.5763	.0237	.0067	34.06
15	.6977	3.3898	21.0265	.0395	.0117	30.14
20	.6582	3.1597	17.6367	.0525	.0166	26.80
25	.6057	2.8992	14.4770	.0517	.0178	23.90
30	.5540	2.6428	11.5778	.0509	.0193	20.90
35	.5031	2.3833	8.9350	.0529	.0222	17.76
40	.4502	2.1092	6.5517	.0567	.0269	14.55
45	.3935	1.8123	4.4425	.0621	.0343	11.29
50	.3314	1.4870	2.6302	.0680	.0457	7.94
55	.2634	1.1432	1.1432	.0695	.0608	4.34
60	.1939					

The resulting central mortality rates ($5m_x$) are represented in Figure 3, together with those corresponding to life tables constructed for Chilean religious and for a population in Nuñoa. It can be observed that the level of the San Felipe rates, in the intervals in which the comparison is possible (over 25 or 35) is higher than in the two other populations. The difference however is now not so exaggerated as it was with the values presented in Table 3, based in the registered deaths, without any correction.

Another analysis of interest, that can be done with the above results, is the one relative to the age composition of the stable population that has the same mortality and rate of increase (5 per thousand per year) than those estimated for San Felipe. The age structure, for decennial groups, of the stable population and of the observed population in the 1787 census, appear in Figure 1, in the upper right section. This analysis points out the marked irregularities which were apparent with only a careful examination of the age structure given by the census.

Figure 3

COMPARISON OF THE CENTRAL MORTALITY RATES 5^m_x ,
SAN FELIPE, CHILEAN RELIGIOUS, POPULATION OF ÑUÑO A



IV. CONCLUSIONS

The application of a method recently proposed by Professor William Brass is illustrated with rather inappropriate data for measuring mortality since the correspondence between the information on deaths and the information on the population enumerated in a census is doubtful.

If we calculate mortality rates by age, relating the number of registered annual deaths, to the number of enumerated persons, we obtain apparently exaggerated values. The method of analysis used, permits to establish that the data of the registers and of the census, can be conciliated if only 60 percent of the registered deaths are taken into account.

Limiting the analysis to the 10-60 age interval, we correct the figures of registered deaths and a truncated life table is constructed, between the mentioned ages.

The resulting mortality level is compared with two existing estimates: one relative to Chilean religious (XVIII and XIX centuries), the other to a population in Nuñoa (1866-1871). It is higher than those estimated for the two mentioned populations.

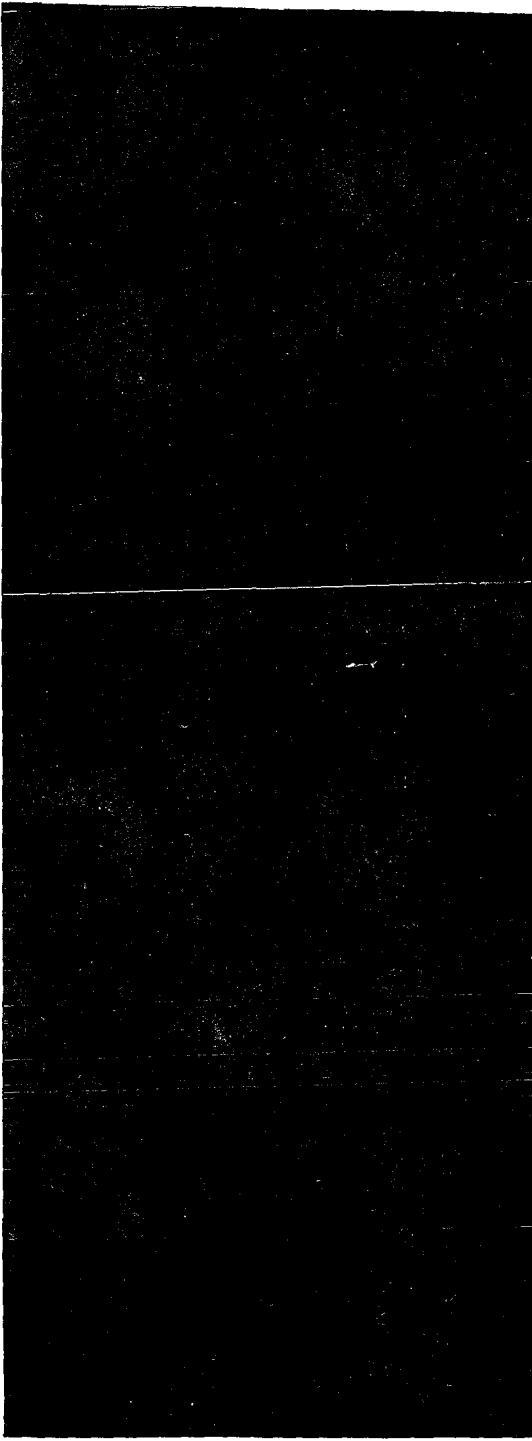
The age structure given by the census is satisfactorily close to one corresponding to a stable population, with the same mortality as that estimated for San Felipe, and with a rate of natural increase also derived from the application of the Brass method.

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