

SOCIETAL AND ECOLOGICAL DETERMINANTS OF URBAN HEALTH: A CASE STUDY OF PRE-REPRODUCTIVE MORTALITY IN 19TH CENTURY GIBRALTAR

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Abstract—A historical based enquiry of colonial Gibraltar at the turn of the 19th century was conducted in order to assess what factors gave rise to residential variation of pre-reproductive mortality. Gibraltar's unusual configuration of a port city, garrison town, and commercial centre at the tip of the Iberian peninsula offers a unique opportunity to examine the interplay of ecology, demographic and socio-economic factors on childhood mortality. Communal living under the patio system and the sharing of essential resources were characteristic features of life on the Rock. Using the residential district as the focus of enquiry, stepwise regression results for the period 1879-81, designated as a period of 'low ecological stress', indicated that the number of gallons of potable water per person captured a significant amount of variability in mortality. During the year 1878, a serious shortfall in rainfall was associated with lower life expectancy, a change in the seasonal pattern of mortality, and elevated rates of deaths attributable to the diarrhea complex. Under this period of 'high ecological stress', the percentage of servants in the household, a proxy for wealth/status, proved to be the single most important factor accounting for 46.6% of the variation in the death rate under 15. Analysis of mortality at the patio level revealed that residents of buildings of two household units had lower mortality than residents living in smaller or larger dwellings, particularly in the period of high ecological stress. The complex pattern of mortality at the district and patio level is explained in terms of the development of residential preferences and decentralized nature of vital resources, such as the water support system and food supply.

Key words—communal living, rainfall, mortality, water, food, urban ecology

INTRODUCTION

Described literally as 'deathtraps of mankind', urban centres in most westernized countries prior to 1900 subjected their inhabitants to crowded living conditions, poor sanitation, increased inter-personal contact, and at times, excessive mortality through acute infections. Chances of survival for the young were particularly poor owing to the rapid accumulation of insults from the urban environment. Yet, the mortality experience of urban dwellers was not homogenous in magnitude nor in cause. Given differences in housing conditions, occupational and/or ethnic segregation, refuse disposal and in the water support system, it comes as no surprise that there were marked differences in the mortality rate according to spatial location within the varied and complex urban landscape. However, with few exceptions [1-5], the epidemiological history of single urban centres and intra-city variation in mortality rates has escaped the attention of most investigators.

Part of the reason may lie in the inherent problems of urban research. First, the sheer size of cities presents formidable problems in terms of data collection and analysis. Second, owing to their openness and fluidity of urban centres, it is often difficult to delineate the boundaries of the target community and

temporal comparisons of the same unit becomes next to impossible. Finally, a key factor in urban growth has been massive and continuous immigration and accordingly, identification of the permanent resident vs the transient is often problematic. Definition of the 'fixed' and 'floating' population are, of course, critical in the computation and subsequent interpretation of any mortality statistic.

Owing to its unusual topography, strategic location and singular socio-political history, Gibraltar provides the researcher with an unusual opportunity to conduct historical epidemiology of a single urban centre and its population. The habitable portion of Gibraltar is small and limited. By the mid-19th century, population growth was curtailed due to a shortage of housing, a high cost of living and an effective immigration policy. By the 1870s, Gibraltar's inhabitants were clearly delineated into three distinct and separate spheres: the local civilian community, a large transient group whose numbers varied daily and finally, the ruling 'outsiders' headed by the Governor, his colonial administrators and the military. Vital information on the civilian inhabitants is available from three independent sources: parish or synagogue registers, nominative census rolls and government registers of births, deaths and marriages. The comparatively small number of inhabitants and

Table 1. Population of Gibraltar as of 31 December 1878

	Area in square miles	Civilian	Military	Total	Persons per square mile
Town	0.25	15177	2740	17917	71668
Rock	0.875	51		51	58.3
South	0.5	2335	4285	6620	13324
N. Front and Catalan Bay	0.25	431	702	1153	4612
Total	1.875	18014	7727	25741	13728.5

excellent registration system permits the investigator to readily identify and track individuals over time. Despite its physical size and demographic numbers, Gibraltar contains sufficient heterogeneity in terms of occupational diversity, religious affiliation and sanitary conditions to undertake an exploration of mortality differentials.

The goal of this paper is primarily exploratory as it seeks to describe the range and level of mortality experience of the young inhabitants of fortress Gibraltar. In order to capture broad general features of the urban landscape the unit of analysis will be the residential district as well as the communal dwelling unit. Proxy measures of crowding, the status of the water support system and social and economic segregation are constructed and used to account for the variability in inter-district mortality. The emphasis on deaths under the age of 15 years is envisaged here as an indication of prevailing sanitary conditions, the health delivery system and the overall nutritional status of the community. In order to minimize intra-city movement that might, in turn, obscure any spatial differentiation in mortality rates a temporally limited span of 4 years was employed as the study period.

The period under investigation is *ca* 1878 at which time Gibraltar's sanitary environment was probably at its worst, there was serious overcrowding, limited health care and low survivorship. The choice of this temporal period was influenced by a number of other factors. First, the vast majority of pre-reproductive deaths occurred at home and not at the Civil Hospital and consequently, these deaths could be directly linked to their respective place of residence. Second,

compulsory civil registration of deaths which had been in place since 1869 had by this time established the legal requirement and social tradition of reporting deaths to the civil authorities. Third, the period was free of any major epidemic, particularly measles, which would adversely affect the mortality profile of the children. Finally, the period can also be characterized as one devoid of a modern paradigm of disease etiology as well as a period where medical care of the young was relatively ineffective.

THE SETTING AND THE '1878' POPULATION PROFILE

Gibraltar may be described as a bold promontory of limestone jutting insularly into the sea at the entrance of the Mediterranean. A peninsula of oblong form, it is attached to the southern tip of Andalusian Spain by a flat sandy strip of land 10 ft above sea level. Running nearly due north and south, Gibraltar is about 3 miles in length, greatest breadth $\frac{3}{4}$ mile, and circumference about 7 miles. The territory covers approx. $1\frac{7}{8}$ square miles while the town proper occupies a mere $\frac{1}{4}$ of a square mile. As Table 1 indicates, population density, particularly in the town, was extremely high and comparable to the most densely populated cities in western Europe.

The salubrity of Gibraltar's climate has been said to have attracted the infirm and unhealthy for countless centuries [6]. The general character of the climate was said to be very agreeable from November to May, but the remaining 5 months are considered hot. The diurnal variation in temperature is fairly small as can be seen by the average minimum and maximum monthly temperatures shown in Fig. 1. The hot

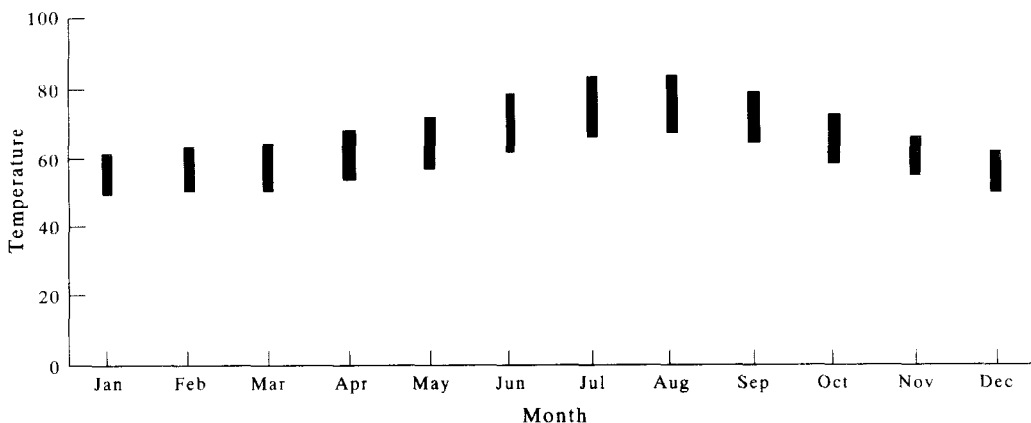


Fig. 1. Monthly average maximum and minimum temperatures. Gibraltar: 1860-99.

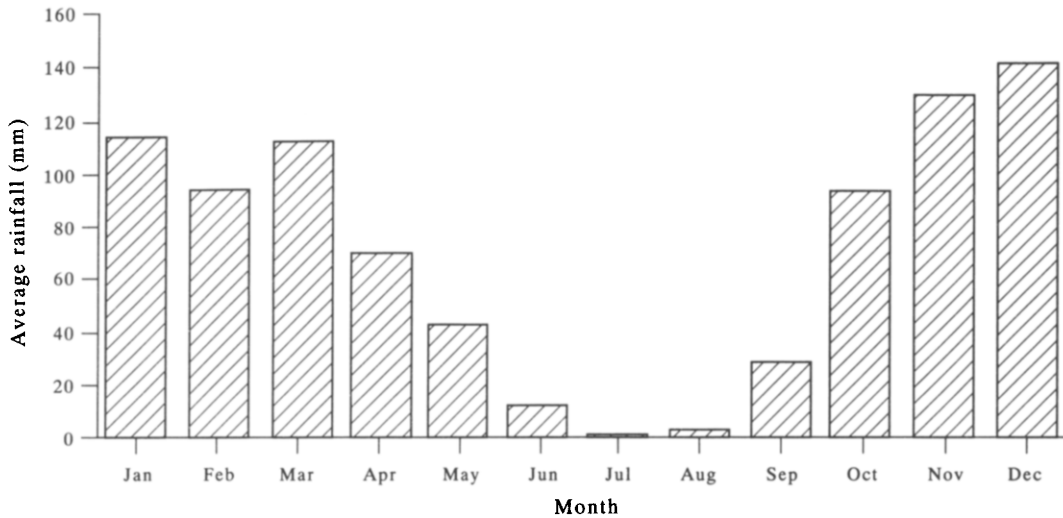


Fig. 2. Average monthly amounts of rainfall. Gibraltar: 1860–99.

summer months, July and August, are occasionally made to feel oppressive when the easterly winds, or Levanter, brings in a heavy moisture-laden cloud that hangs over the town at times for days on end. Like most of the Iberian peninsula [7], Gibraltar receives most of its rainfall in the cold half of the year (winter and autumn). After the rains of November–March there is a long period of drought lasting from June to August. The occurrence of a well-marked dry season, a characteristic of the Iberian peninsula, is clearly defined in Gibraltar (see Fig. 2). The average rainfall taken from 1860 to 1899 was 865.9 mm.

In 1878, 15,222 civilians were packed into the old

walled city that occupied the northwest face of the promontory. A large portion of the town, about a third of the whole, was built on a strip of comparatively flat ground between the steep slope of the rock and the line wall from 12 to 20 ft above the high-water mark. The remainder is built chiefly on the slope on terraces, one over the other, rising to an elevation of 250 ft above sea level.

The age sex profile of Gibraltar’s urban inhabitants revealed a broad-based pyramid suggestive of a ‘young’ expanding population (see Fig. 3). A modest excess of females resided in the fortress as the overall sex ratio stood at 112.6 females for every 100 males.

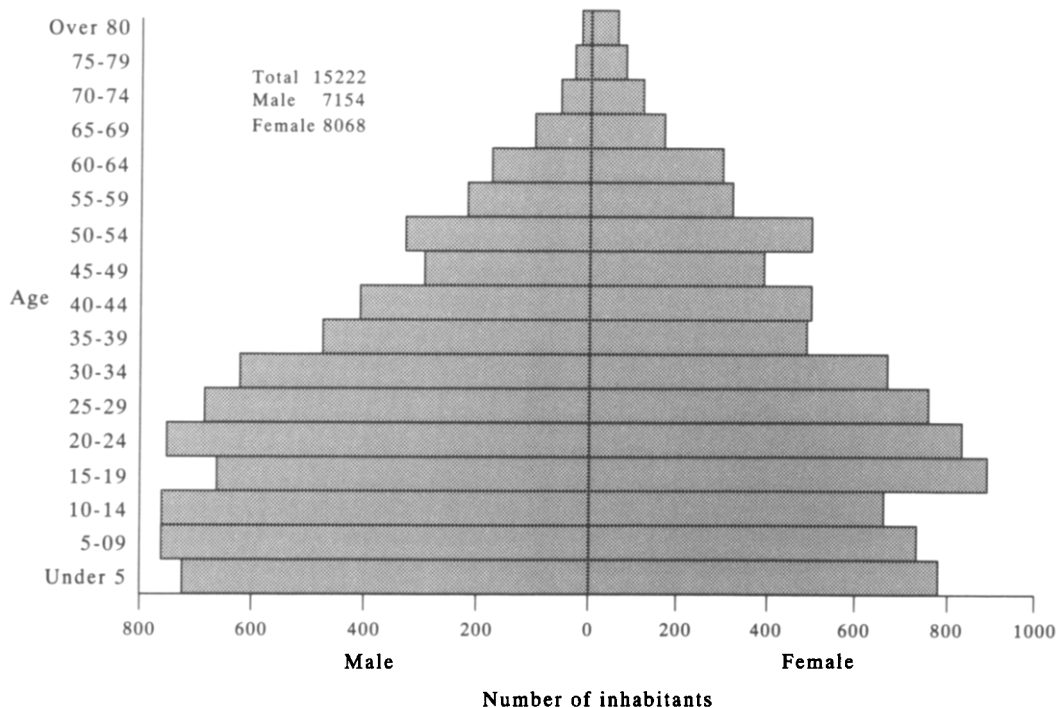


Fig. 3. Civilian residents of the town of Gibraltar: 1878.

Partitioning the population into three broad major stages of the life cycle revealed that about two-thirds of the population were adults (15–64). The youth component, or population under 15 comprised 29% and the aged a mere 3.9%. The median age stood at 25 years. Roman Catholics numerically dominated Gibraltar's urban centre with 12,298 souls, or 81.03% of the total; while the Jews and the Protestants comprised 9.57% and 4.86% of the city's population, respectively.

With the exception of its' strategic location, Gibraltar has little in way of natural resources. The greater part of the Rock is incapable of cultivation and the inhabitants of Gibraltar are dependent on food imported from the Spanish mainland, Morocco or from abroad. Much of the available territory suitable for building is occupied by Naval or Military Works and the population is packed into a space which makes housing extremely difficult. The lack of space for expansion has been an ever present source of anxiety among the civilians.

THE GIBALTARIANS

As residents of a garrison town and citizens of a small British Colony since 1704, Gibraltarians gradually developed a distinctive ethos. Gibraltar is small-scale community where face-face contact of its members is a daily occurrence. The primary units of social reference were and continue to be the extended family, the patio, occupation, religious affiliation, and the local neighbourhood. A fusion of Mediterranean and European cultures, the Gibraltarian character emerged out of two centuries of colonial and military rule. As the result of their political marginality and the lack of any effective control over their civilian affairs a blend of a colonial and garrison town mentality developed among the civilian inhabitants. Rooted in the tradition of living in a fortress and at times under siege, the inhabitants of Gibraltar have been acutely aware of their heritage. Neither British nor Spanish in character, Gibraltarians saw themselves as a people apart and positioned several rungs below the ruling British elite. The preferential treatment of outsiders from the 'British Empire' in terms of position, housing, wages and mobility reinforced the real and perceived social hierarchy. The rigid class structure permeated every aspect of civilian life and prevented any possibility of upward mobility and intermingling. Differences in religion, language, customs, and quality of education imposed additional barriers on any meaningful social intercourse between the colonial administrators and the military with the residents of the local community [8].

The social distance between the Spanish and the Gibraltarian was equally wide. Gibraltarians typically place themselves far above their Spanish neighbours even though a significant portion of the ancestral population originated from Spain. This perception was also shared by their Campo neigh-

bours, for a marriage to a Gibraltarian or gainful employment in Gibraltar, was seen as a significant step up the social and economic ladder for most Spanish workers and domestics. For most Gibraltarians social mobility was, however, limited to their own community as locals could never attain real political power. The lack of political autonomy among the local inhabitants continued well into the 20th century. Owing to its status as a Crown Colony, Gibraltar's civil administration was entrusted to a military Governor in whom is vested the full legislative power as well as the full executive power. The civil population have no say in the appointment of their ruler and no right to vote locally or in England. Legislative power in Gibraltar was largely exercised by Ordinance. Triay, a leading local physician, succinctly characterized the feeling of many Gibraltarians when he stated, "the regime prevailing, . . . as between those who govern and those who are governed, is still more in accordance with the relationship to be expected between the conquerors and the conquered" [9].

Power was therefore always held and seen to be held by 'outsiders'. Consequently, the native population had little or no effective voice in any improvements in the local health care facilities, water support system, and public sanitation. From the perspective of the Governor and his officials, the term 'native' was a term that became one denoting inferiority, despite British citizenship [10]. The medical and sanitary history of the community was therefore, in the main, determined by external forces. Denied the opportunity to invoke change in their immediate physical environment and living under military subjugation Gibraltarians developed a world view of a colonized people that may have influenced their health and welfare.

PORT, FORTRESS AND COMMERCIAL CENTRE: HEALTH IMPLICATIONS

Despite its comparatively small numbers and diminutive physical size, the potential for high and episodic mortality was great owing to Gibraltar's unusual urban configuration of port city and naval base, garrison town and commercial centre. Throughout its history under the British flag, Gibraltar was an important port of call for both merchant and war vessels, as a coaling station, and for a brief period, as a major mercantile centre. As a result of its free port status and strategic location, Gibraltar served as an important node in a trade/military network, linking numerous urban centres throughout Europe, the Mediterranean, Africa and the New World into a large reservoir of potential hosts for infectious disease. Such movement of people and goods efficiently and effectively facilitated emergence of a global pattern of disease transmission [11–13].

In addition to infrequent but important contact with 'distant outsiders', the inhabitants of the Rock

came into contact with numerous strangers daily. The average number of aliens entering Gibraltar was about 1500 daily on weekdays and on occasion as high as 4000 on a single day. Gibraltar's lack of natural resources and shortage of labour compelled the colonial authorities and the military to seek food, goods and services from its nearby Spanish and Moroccan neighbours. Seeking either refuge, steady employment, higher wages or the opportunity to make quick fortunes, large numbers of foreigners, numbering in the thousands, entered the walled city of Gibraltar daily. Foreign labourers, domestics, hawkers, petty dealers and traders mixed with the locals, military and colonial officials giving English held Gibraltar an almost surreal atmosphere. The constant flow of foreigners in and out of the walled city not only provided a cosmopolitan flavour to the city but also fuelled population growth. Despite the deplorable living conditions, overcrowding and high cost of living, Gibraltar's dynamic economy acted as a powerful magnet drawing thousands of young, mostly unskilled, adult men and women from the Spanish countryside. In fact, explosive migration-driven growth was a predominant feature of Gibraltar's history during the first three decades of the 19th century. During this interval, the civilian population increased from 5339 individuals in 1801 to 17,022 by 1830.

Not surprisingly, the British authorities were alarmed at the unbridled growth of civilian population and at times almost xenophobic of the demographic and social consequences of the large numbers of foreigners resident in fortress Gibraltar. Numerous proclamations and ordinances were enacted during this period to combat the rising flood of immigrants. Gradually a complex permit system evolved to meet the labour and commercial needs of the garrison. Colonial administrators were particularly apprehensive of disease transmission to the garrison troops from local inhabitants and resident strangers, and in response developed strict quarantine procedures. This fear was well founded for in the past Gibraltar had been devastated by a series of epidemics of yellow fever and cholera [14].

Gibraltar's status as a garrison town served to facilitate the transmission of diseases from 'outsiders' to its civilian inhabitants. While the 'strength' of the garrison varied over time, the military presence on the Rock was formidable. In 1878, the military and their wives and children numbered 7707 and comprised approximately one third of the total resident population. The military dominated all aspects of life on the Rock; their distinctive speech, dress and manner heightened their presence and visibility. The fact that a large number of military were housed in civilian quarters and not simply confined to a single portion of the Rock further strengthened the 'fortress air' of the city. To the civilians of the Rock, the military way of life epitomized order, power and domination.

In the town proper, a total of 2740 military personnel lived in immediate and close proximity to the civilian population in 1878. Despite the interlacing of military and civilian accommodations in the town, the two communities remained socially segregated. For the most part, there was little communication between the two groups beyond the occasional marriage of a soldier and a local woman. There was one important exception. Gibraltar's brothels, although few in number and staffed largely by Spanish women, linked both civilian and military communities. The transmission of diseases, and in particular sexually transmitted infections, was greatly enhanced by Gibraltar's status as a garrison and port city.

THE CITY AND LOCAL CONDITIONS

After the widespread destruction of the town during the Great Siege of 1779–83, the city of Gibraltar was rebuilt along the old Moorish plan which was originally based on the housing and sanitary needs of a much smaller population. Gradually the infrastructure of the city was transformed by the British and in particular, during the administration of Lieutenant-Governor George Don, a man of vision and political acumen [15]. Under the enlightened guidance of Don, Gibraltar underwent a radical transformation in terms of its buildings, institutions and sanitary works. To affect a more comprehensive control of the city populace and watch over the health of the inhabitants, Don divided the town in December of 1822 into 28 administrative districts, each with its own inspector(s) chosen from "the most respectable" of its inhabitants. After Don's death, Gibraltar was less fortunate in its appointment of a Governor and the prosperity of the early 19th century that fuelled many of the public works also declined.

The social geography of the city *ca* 1878 was a gradual spatial response to the accumulation of a number of disruptive forces in which the poor and working classes were forced to find shelter in substandard housing in less desirable portions of the city. It is difficult to establish when precisely Gibraltar began to display its variegated landscape of distinct neighbourhoods based social and economic differences. Perhaps the earliest manifestation of socio-economic segregation began shortly after 1815 when Governor George Don ordered that wares and merchandise could no longer be sold at stalls or benches at corners of streets, Commercial Square or elsewhere in the city. By encouraging a more settled business life based on shops [10], the Governor put into motion an ongoing process that was to profoundly influence the pattern of civilian housing in Gibraltar. By replacing precious residential space (specifically ground flats in the commercial areas) with space for shops, warehouses and workshops, the poor were forced to seek shelter outside the newly formed commercial core. As was stated earlier, it was precisely at the turn of the 19th century when Gibraltar began to experience an

explosive population increase through massive migration. The influx of foreigners and British into the crowded fortress strained the available accommodation. Property values rose dramatically and house rents rose according to demand.

The shortage of affordable housing for the poor became even more acute as small numbers of the more well-to-do families moved into the commercial areas and occupied the large buildings which had once accommodated more than a hundred or more poor families. Further attrition occurred at the hands of the Government when the colonial authorities rented out large buildings which had once housed hundreds of civilians for the use of married soldiers and their families. The destruction of buildings in order to comply with new sanitary regulations and to make way for the construction of public buildings (such as churches and an asylum) added to the dearth of housing for the working classes. Finally, stringent military restrictions exacerbated the housing shortage as fortress exigencies placed restrictions on the form and position of buildings. One such restriction for instance was that the height of buildings could not exceed 50 ft. Yet another example was that when building space did become available military authorities refused to agree to any building plans which would increase the available living accommodations. As a consequence of these restrictions and other factors, the number of houses for civilians actually decreased from 1814 until the 20th century.

The common practice of interspersing of light industry with residential housing not only restricted the number of accommodations but also could adversely affected the health of the residents in specific neighbourhoods. A common feature of Gibraltar's urban landscape was the frequent location of small tobacco factories often on the main floors of residential buildings. By the mid-1800s, approx. 2000 men, women and children were involved in the manufacture of tobacco, either in crowded, poorly ventilated 'tobacco factories', or in their homes [16]. It was not uncommon to find in the medical reports observations of a mother with infant or child toiling in the dust-ridden tobacco shop. Unskilled, poorly paid labourers and their unfortunate neighbours co-existed in a neighbourhood with elevated levels of noise, smell and tobacco dust. Medical authorities in Gibraltar had long recognized the health problems of working with tobacco but they too were caught on the horns of a dilemma; that is, weighing the economic benefits to the poor labourers (and of course, their wealthy employers) with that of the health of the workers and local inhabitants.

Unlike some of the large industrialized American cities where the city centre was the watershed for the poor and recent immigrant, Gibraltar's commercial centre housed primarily the rich and privileged. While the wealthy were accommodated in spacious and elegantly fashioned marble-adorned patios, the poor were cramped into poorly-constructed, damp, grossly

over-crowded, pestilential quarters. The majority of the local inhabitants were compelled to reside in small, typically one-room, cramped apartments. An analysis of household structure from the 1878 census rolls indicated that approximately one-quarter of the households were either extended or multiple family units. Housing conditions were such that a leading physician once proclaimed, "in fact, when the weather is fine, the open street is much more desirable, than many of the lodgings of the lower orders of the inhabitants of Gibraltar" [6]. The absolute lack of any degree of privacy and the deplorable state of affairs that could be found among the tenements of the poor was aptly captured by a sanitary engineer when he observed,

This house [House 23 District 27], . . . , is a long building of two stories' each being divided into eleven separate rooms, all being occupied by separate families consisting of 5-12 persons in each. . . . a large privy (is) used by nearly 200 persons of both sexes, and is in such a filthy condition as to be most dangerous to health, it is a large hole over an open drain which is separated by a long open iron grating; the smell from this privy is distinctly perceptible 30-40 yards off. . . . the floors are brick, apparently laid on the earth, and the ceilings of thin deal boards laid on unceiled joists, so that there is only one inch of wood as a division between one dwelling and another. There are no kitchens to these houses, so that cooking is carried on almost entirely in small portable charcoal stoves [17].

In the absence of any rent control and a constant shortage of living accommodations tenant rights were virtually non-existent. The poor were often at the mercy of their landlords, many of whom were non-residents. Lacking the necessary funds and means to secure legal advice against unscrupulous landlords or the opportunity to find alternative affordable housing on the Rock, the power of the landlord over the tenant was absolute. Lists were kept and those who complained quickly received a notice to quit. The only other alternative was to leave and take up residence in the Spanish shanty town of La Linea located less than 1 mile away from Gibraltar. While accommodation was considerably cheaper there, the inconvenience of crossing an international guarded border daily while working in Gibraltar and the stigma of residing in a distinctly working-class environment deterred movement out of Gibraltar for all but the destitute.

While the exterior of the houses in Gibraltar were 'English' in character, the houses and streets of Gibraltar were different in their mode of arrangement and are more similar to those of southern Andalusia. The houses are built around a courtyard, called a patio, and the only way in which they can be accessed is through a narrow passageway. The majority of Gibraltar's inhabitants lived under the patio system; that is, a large, multi-level, tenement in which each apartment overlooked a common courtyard or patio. Single family dwellings were clearly in the minority. Approximately three-quarters of the inhabitants of the town co-resided in buildings that housed 20 people or more.

An important element of the Gibraltarian ethos was the product of long-term residence and membership in a specific patio. The physical structure of the patio was such that each could be seen literally as a self-contained community. Here members of a patio, particularly women, children and the elderly, spent most of their time working and playing. The close proximity and long-term residence in a patio could foster friendship, group identification and the development of strong bonds between its residents that cut across both religious and socio-economic lines. Thus, the patio itself could be of considerable importance as it contained the potential for enhanced communication, group solidarity, socialization of the young, convenience and neighbourly help. The manifestation of the support system could be also seen in materialistic terms such as food or monetary aid. By expanding the support network beyond the immediate family the patio could act as an adaptive organ in the hostile, impersonal urban environment. The theoretical foundations of social support as health enhancing and buffering action can be found elsewhere [18, 19].

Communal living could also impact negatively on the health of its members. Dependence on common facilities (e.g. well and potable water supply, shared entrance, common passageways, and communal laundry and play area, limited number of water-closets) and co-residence in a very overcrowded and poorly constructed building as well as the presence of 'strangers' or temporary lodgers could add significantly to the possibility of ill health. Perception of public and private space was culturally mediated so that the 'outside' of the actual living quarters was seen not as the responsibility of the tenant but that of the landlord or government. Under such conditions, particularly in the case of non-resident owners, it was very likely that the 'outside' or public space would result in an unkempt and unsanitary environment, while the apartment itself, the 'inside' or private space was meticulously clean, well kept and a source of pride among the occupants. The duality of perception of public and private space and the responsibility for its upkeep is an important element of the Gibraltarian ethos that may have had important epidemiological consequences.

Another important element of daily life that involved risk to health revolved around acquiring a sufficient quantity of the first necessity of life, namely drinking water. The case of the water supply in Gibraltar is unusual for unlike most urban centres which are located close to rivers or streams, there is no surface water in Gibraltar. Since the British occupation of Gibraltar the scarcity of water has been cause for concern for the authorities and its residents. In 1862, a Parliamentary Commission on Barracks and Hospital Improvement enquired into the sanitary conditions and improvements of Mediterranean Stations. In evidence given to the Commissioners the garrison Quarter Master observed, "the inhabitants (of Gibraltar) owe nothing to the British Government

for the small supply of water they have had for 150 years" [20]. The Commission also noted that there was not a single waterpipe in the town apart from the old aqueduct. Up until the 20th century, the inhabitants of Gibraltar were dependent on rainfall as their principal source of drinking water. Patio roofs and terraces were used to catch the precious rainfall. Often, no precautions were taken to filter the water before it entered the underground storage tanks, nor were some of the inhabitants aware of the necessity for keeping the roofs of their houses clean, as the terraces were often used for washing and hanging clothes and for keeping poultry.

Roberts estimated in 1870 that the average daily allowance of water to each member of the civilian population was less than 2 gallons per day [21]. In a year when rainfall was below average, the want of water, particularly during the hot summer months, was severely felt by Gibraltar's inhabitants. Long drawn-out droughts represented a serious threat to the population's welfare and as such a period of high ecological stress could directly or indirectly affect the mortality profile of the community.

During the long, hot, dry summer months water could only be purchased or obtained from private underground storage tanks. Medical officers frequently complained about the unsanitary nature of the construction and position of the water tanks. The only satisfactory aspect of this water system was that contamination of one tank would be limited to a single patio dwelling. Many dwellings, especially those of the poorer classes, lacked a private water tank. Owing to its scarcity and the difficulty of its distribution, the cost of water could be prohibitive. During the dry summer months Gibraltar's inhabitants became increasingly dependent on the 'wretched' and 'primitive' system of delivering water to houses in more or less impure kegs. The installation of piped-in-water did not become available to Gibraltar until well into the 20th century and even then it was confined to the houses of the well-to-do and commercial establishments. To aggravate matters, the distribution of drinking water by butts and barrels was largely in the hands of private individuals, usually Spanish day-labourers. Until the 20th century when specific bye-laws were introduced, Gibraltar's Sanitary Commissioners had no effective control over either the cleansing or handling of these water receptacles.

In fact, the Sanitary Commission, originally created in 1815 and expanded to a 12-man body following the cholera epidemic of 1865, had done little in the way to ensure the health and safety of Gibraltar's inhabitants. Up until 1892, the Commission had introduced only one specific byelaw. As Major Tulloch, a Royal Engineer, exclaimed, "... how can a town exist under proper sanitary conditions unless the officials of the local governing body are armed with special powers in their respective departments?" [22]. Calls for reform by various Medical Officers of

Health often went unheeded as the sympathies of the Sanitary Commission seem to be onside with those of the landlords, shopowners and landowners. As has been pointed out by Srezter, "in these circumstances the ambiguity, or positive obstructionism of economizing ratepayers could all too easily prevail over public health arguments for expensive local facilities and services" [23]. Gibraltar was no exception and there is considerable evidence of conflicting interests, whether pecuniary or social concerns, among the inhabitants of the Rock.

The importance of water was not confined just to the potable variety, water for sanitary purposes was either in short supply or under certain circumstances virtually non-existent. Drawn from local wells, sanitary water was used for flushing, cleaning rooms, staircases and patios, for personal ablution, cleaning and cooking food and for washing utensils. The lack of a continuous supply of sanitary water also had an impact on the sewage system. During the rainy period, sewers and drains were effectively flushed out, however, during the dry summer months most of the excreta of the population remained and during this interval the drains and sewers became nothing but offensive and potentially dangerous cesspits. Conditions in the upper part of the town were particularly bad during the dry months as only a small proportion of the patios had ready access to well water.

Bacteriologically the groundwater of Gibraltar has always been described as bad and highly charged with organic pollutants. An analysis of the well water in 1862 revealed that the total nitrates and organic matter was 57.3 grains per gallon. Consequently, the brackish well water was never used for drinking purposes. The ease of contamination was related to the fact that sewage and refuse were often disposed of by leading it to earth pits very near the wells. The simple construction of these wells gave no protection from the water which had filtered through polluted soil. The risk of self-contamination of the ground water with human and animal waste was further enhanced by the porosity of the Rock itself, the pattern of high density residential living and the practise of keeping animals and poultry in close proximity to living quarters.

MATERIALS AND METHODS

In order to examine the complex inter-play of demographic and ecological factors on pre-reproductive mortality a three-tier approach was used in this micro-level investigation. First, the overall pattern of pre-reproductive mortality was explored for the entire town proper for two periods of time, 1878 vs 1879–81. Second, the pattern of childhood deaths according to place of residence was examined by focusing on the large administrative level, the census district. Finally, the mortality experience of members of the same patio was conducted in order to capture the potential effects of communal living.

Since the amount of yearly rainfall for the 1879–81 triennium averaged 1021.3 mm, well above the 40-year norm of 865.9 mm, this interval was designated as representative of a period of comparatively 'low ecological stress'. Marked by a serious shortfall in rainfall (411.1 mm), the year 1878 was used as a reference point to denote a period of 'high ecological stress'.

Demographic information was compiled from housing surveys taken in 1879 and from information extracted from the nominative census rolls of 1878. Since the published census provided only a broad summary of statistics by age and sex as a whole, information from the original nominal rolls was entered into a computerized data base. Deaths covering the period 1878–1881 were transcribed from the civil death registers into a separate data base.

Following the methodology of Chiang [24], estimates of life expectancy for 1878 and 1879–81 were used as a summary measure of mortality. Cause-specific mortality, retrieved from primary cause of death listed in the civil death registers was grouped into 9 broad categories. Following the rationale outlined by Sawchuk, Herring and Waks [25], deaths due to diarrhea, gastro-enteritis and difficult dentition were pooled into the category called 'the diarrhea complex'. Deaths attributed to malnutrition included atrophy, marasmus, malnutrition and 'want of breast milk'. Diseases of infancy included deaths due to prematurity and immaturity. Cause-specific mortality was computed as the number of deaths under 15 years attributed to a specific category per 1000 individuals aged 15 and under.

In order to examine the relationship of pre-reproductive mortality and place of residence at the district level linear multiple regression was employed. The unit of investigation is the collectivity of the mortality experienced by all the members as a whole within a district and not the individual *per sec*. Despite interpretative problems associated with the ecological approach [26, 27], such a strategy can serve as a starting place for further research as well as providing information on broad social and cultural processes. Pre-reproductive mortality is considered as the dependent variable. A weighted least squares method was used in order to satisfy the assumption in regression analysis of a common error term as well as the fact that the dependent variable was a proportion. The weights employed were derived from the reciprocal of the variance in the district pre-reproductive mortality rate. Under such an approach, districts with very few deaths under 15 did not contribute disproportionately to the overall regression analysis. Three broad categories of explanatory variables were employed to account for inter-district variation in the mortality rates: (1) crowding measures, (2) water support system and (3) aspects of socio-cultural system.

Proxy measures of crowding used here included (i) the area of the district inhabited by the civilian

population, (ii) the number of square acres available for each person and (iii) the median number of persons per building. The last two variables are designed to address the issue of increased population density and its affect on increased mortality largely through the elevated incidence of infectious diseases. The construction of an objective measure of crowding was severely hampered owing to the fact that the census did not contain information on the number of rooms occupied by each household unit. Furthermore, the perception of crowding and usage of space for living space, another important aspect of crowding, could not be addressed here as well. Consequently, the measures employed here are necessarily crude and devoid of cultural context.

Two measures of the water-support system were employed. First, the average number of gallons of potable water per individual from underground storage tanks for each district was used as a proxy for the amount of drinking water available. Such a measure ignores the fact the water requirements vary by age, sex and other compositional features of the household. Second, the availability of sanitary water was evaluated on the basis of the number of wells per patio in each district. Given the absence of information on the amount of sanitary water yielded from each well this latter measure is quite crude.

Three measures of social and/or economic segregation employed here are: (i) the percentage of households with a servant, (ii) the percentage of Jews residing in each district, and (iii) the percentage of the population in each district that were migrants.

The use of the presence of a servant in the household as a proxy of wealth circumvents many of the problems of assessing socio-economic status based on occupation alone. The difficulties of using occupation as a measure of wealth/status are numerous and beyond the scope of this paper (for a more comprehensive discussion see Refs [28, 29]). Up until the border closure of 1969, the presence of a servant was a characteristic feature of the better-off Gibraltar household. Cheap and plentiful domestic help from Spain, an avoidance of doing manual labour, and a certain cachet of having a live-in servant all provided stimuli for the common practice of having household servants. The potential for religious and economic segregation exerting pressure differentially on the pre-reproductive experience at the district level was explored through the construction of the percentage of Jews residing in a given district. It is important to note here that the Jews of Gibraltar were never involuntarily segregated, either in 'ghettos' or in 'mellahs', from the larger 'gentile' population. In fact, a significant number of Jews held property in Gibraltar. By virtue of their almost exclusive and long-standing tradition of participation in the mercantile activity of the Rock many of the Jews occupied some of the better 'patios'. Finally, the migration variable was ascertained by an examination of the nominative census returns and those individuals whose presence

in Gibraltar was dependent on holding a permit of residence. The migration variable was created in order to explore the possibility that areas of high proportions of non-residents or aliens would be associated with lower levels of social integration and in turn, this would be associated with increased childhood mortality.

In order to gain insight into the inter-relationships of demographic and ecological aspects on pre-reproductive mortality at the level of the dwelling unit, multiple classification analysis (MCA), a multivariate statistic, was employed [30]. MCA allows for the assessment of the effect of each variable before and after adjusting for the level of a factor (e.g. the number of households in a dwelling unit) as well as covariates (e.g. the amount of drinking water per person) on the rate of pre-reproductive mortality. A total of 631 dwelling units in the town of Gibraltar satisfied the criteria for inclusion; that is providing the necessary demographic information as well as precise information on the number of wells and the size of the water tank for each house. Demographic variables treated as covariates included: (i) the total number of individuals in the dwelling unit, (ii) the percentage of households in the dwelling unit with extended or multiple families, (iii) the average age of the members of the dwelling unit and, (iv) the percentage of households in the dwelling unit with a servant.

RESULTS

(i) The overall pattern of pre-reproductive mortality

Table 2 presents summary data on the life expectancy for ages 15 and under for 1878 and the interval 1879-81. The life expectancy at birth for 1878 is estimated at 37.68 years \pm 1.53. Over the next 3 years, a period of average rainfall, the life expectancy at birth rose to 46.70 years \pm 0.92. The difference in life expectancy at birth between the periods of low and high ecological stress was nine years. A comparison of life expectancy for one year olds revealed that the difference in life expectancy remained large with roughly 6 years separating the two periods. The difference in life expectancy continued to fall with less than 3 years separating the two periods until the last two age intervals where the difference was less than

Table 2. Life expectancy estimates for Gibraltarans for the periods 1878 and 1879-81

Age interval	1878			1879-81		
	<i>Dx</i>	<i>e(x)</i>	SE <i>e(x)</i>	<i>Dx</i>	<i>e(x)</i>	SE <i>e(x)</i>
0-1	81	37.68	1.525	131	46.70	0.923
1-2	39	45.19	1.553	72	51.12	0.902
2-3	4	50.30	1.424	28	54.27	0.833
3-4	8	51.83	1.327	13	55.07	0.788
4-5	2	52.34	1.254	7	54.94	0.763
5-10	6	51.65	1.242	34	54.32	0.755
10-15	6	47.65	1.198	7	51.33	0.702

Where *Dx* represents the number of actual deaths *e(x)* and SE *e(x)* represent the life expectancy and its associated standard error.

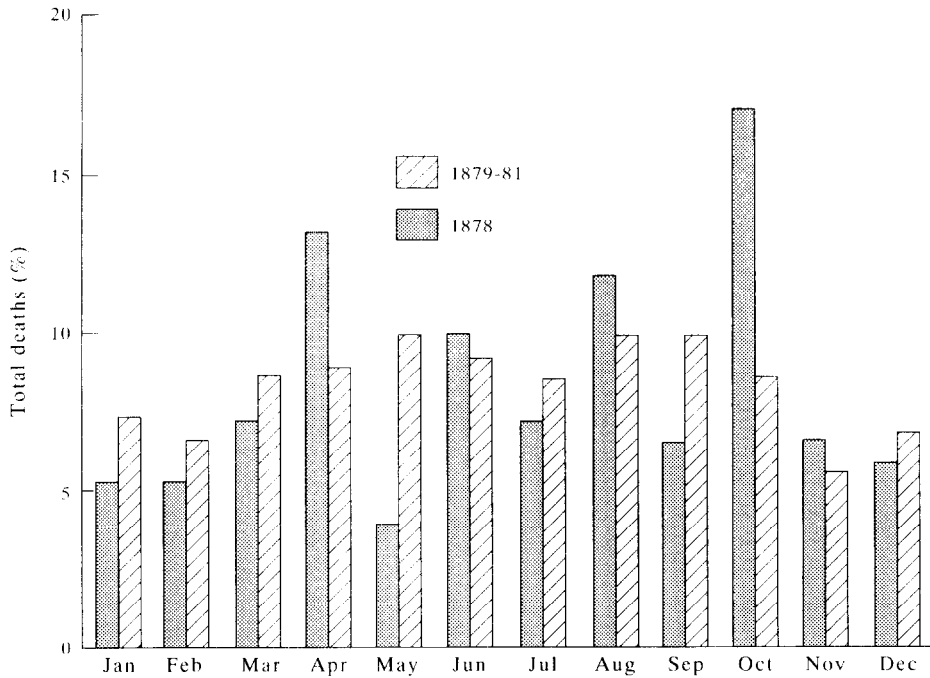


Fig. 4. Seasonal distribution of deaths under 15 years.

4 years. As Table 2 shows the greatest dampening of survivorship in 1878 occurred among children under 2 and in particular among infants.

An examination of Fig. 4 reveals that during the years 1879-81 the seasonal pattern of pre-reproductive mortality, as revealed by percentage of deaths by month, displayed a modest elevation during the spring and summer months with lower mortality during the fall and winter. Given the temperate climate of Gibraltar (see Fig. 1), these results are not surprising. The pattern for 1878 deviated from this

trend by showing a marked peak during the month of October. This is precisely when water resources would be at their absolute minimum after a long drought. Higher levels of childhood mortality were also experienced during April and August of that year.

Figure 5 sets out cause-specific pre-reproductive mortality rates for the periods of high and low ecological stress. The most marked disparity in the rates can be seen in terms of the diarrhoeal complex where there was a 1.69 fold increase in the mortality

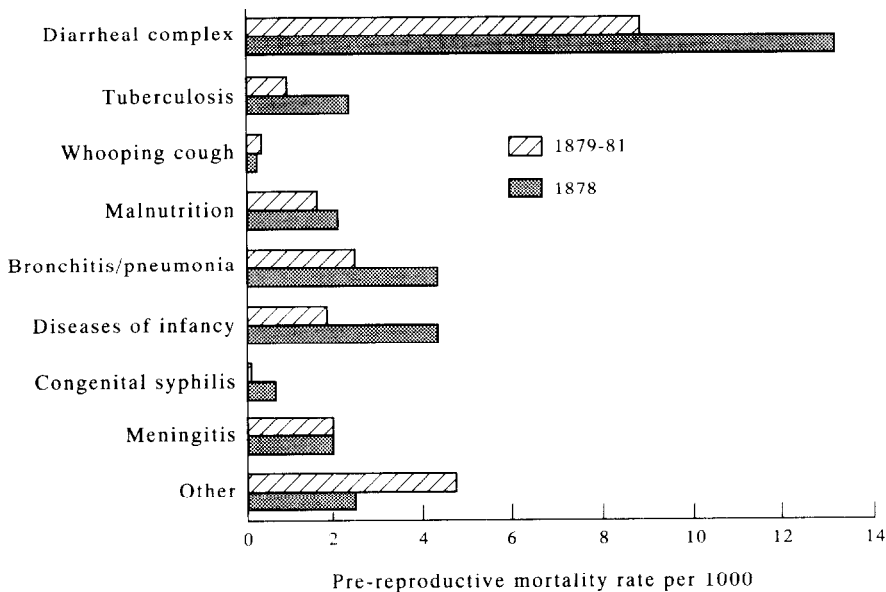


Fig. 5. Cause-specific pre-reproductive mortality rates.

Table 3. Correlation matrix for residential districts with demographic, water support and socio-economic variables for 1879-81

Area	Density	House size	Potable water	Sanitary water	% migrants	% Jews	% servants	
Density	0.134							
House size	0.281	-0.137						
Potable water	-0.511	0.361	-0.590					
Sanitary water	-0.530	0.564	-0.652	0.678				
% migrants	-0.628	0.321	-0.711	0.726	0.882			
% Jews	-0.490	0.398	-0.667	0.702	0.816	0.729		
% servants	-0.623	0.437	-0.684	0.692	0.857	0.867	0.738	
Mortality rate	0.435	-0.283	0.566	-0.585	-0.488	-0.448	-0.482	-0.564

Where area is measured in yd², density in yd per person, potable water is gallons per person, sanitary water is the number of wells, the percentage of migrants, Jews and servants per total number in each district, and the mortality rate is the number of deaths under 15 per 1000 aged 15 and under.

rate of 8.71 in 1878 to 13.07 for 1879-81. A more modest increase was also noted for deaths attributable to pneumonia/bronchitis as well as deaths due to prematurity.

In sum, the differences in life expectancy, the monthly distribution of childhood deaths and cause-specific mortality suggest that local conditions and in

particular, rainfall could play a major role in shaping the mortality profile of Gibraltarians during the 1870s.

(ii) The district level of analysis

Scrutinization of the correlation matrix presented in Table 3 reveals a complex set of interrelationships

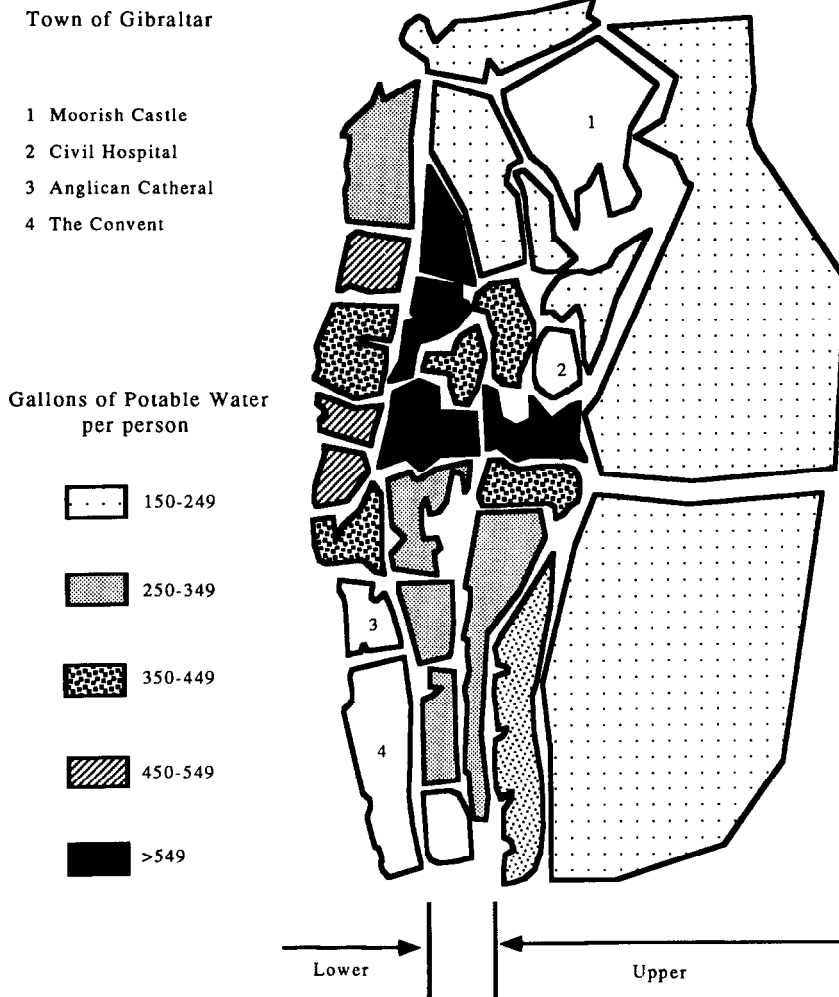


Fig. 6. Gallons of potable water per person by district for 1878-81.

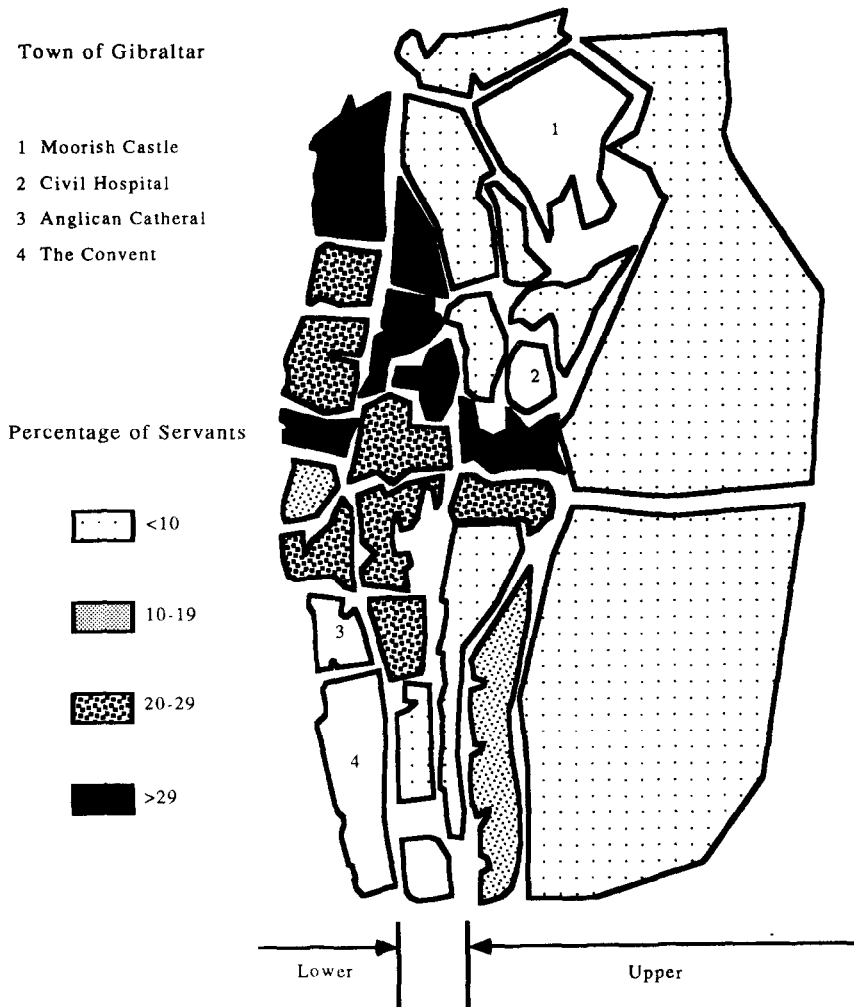


Fig. 7. Percentage of servants in households by district for 1879-81.

between the ecological, demographic and socio-economic variables. As expected at the district level, there is a significant positive association between wealth/status, as measured by proportion of servants, and the availability of drinking and sanitary water as well as the amount of living space. Figures 6 and 7 show the complex pattern inter-district variability with respect to the availability of potable water and the percentage of servants per district. The upper portion of the town had the lowest percentage of servants in the households and can generally be seen as the areas of high concentrations of poor working classes. Lower amounts of potable water can be seen in the upper portions of the town. An inverse relationship was found between the percentage of households with a servant with median household size. In other words, wealthier families tended to live in buildings of smaller size than their poorer counterparts.

During the interval 1879-1881 the standardized mortality rate averaged 23.36 per 1000 individuals under the age of 15. There was considerable variation

between the districts with mortality rates ranging from 6.62 to 49.44 per 1000. The coefficient of variation stood at 41.95%. The absence of any widespread spatial pattern of mortality is aptly demonstrated in the patch work nature of inter-district pre-reproductive death rates seen in Fig. 8. Pockets of high mortality can be seen throughout the middle and upper portions of the town, and in particular in the northern end of the city. Pre-reproductive mortality rate for the year 1878 rose to 33.23 per 1000. The disparity between periods of high and low ecological stress was considerable (9.87 per 1000 individuals under 15). The results of stepwise regression analysis, shown in Table 4, indicate a highly significant coefficient for the potable water variable ($t = 3.383$, $P = 0.0027$). This variable accounted for 31.23% of the overall variation observed in inter-district mortality during the period of low ecological stress. During the period of high ecological stress the results indicate that wealth as measured by the presence of a servant proved to be the best single

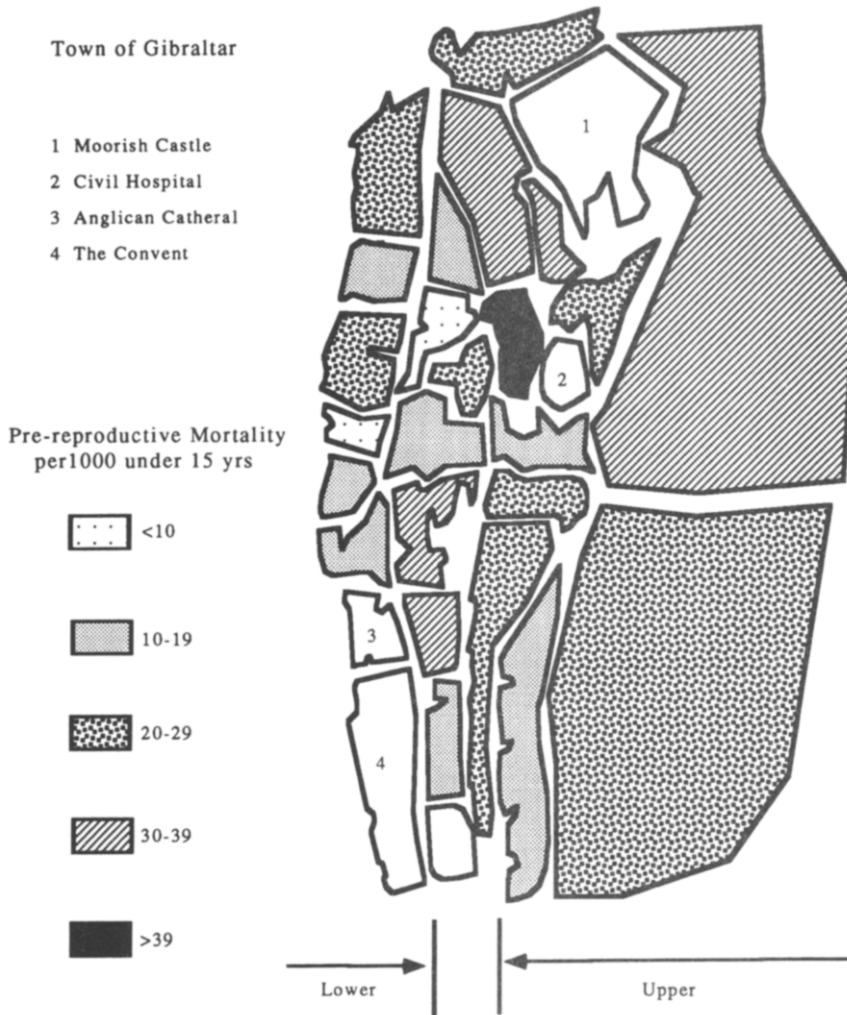


Fig. 8. Pre-reproductive mortality rate by district for 1879-81.

predictor of variation in pre-reproductive mortality ($t = 4.589, P = 0.0001$). The percentage of households with a servant, the proxy for wealth, was able to explain 46.58% of the observed variation in inter-district mortality during the year 1878.

(iii) *The patio level of analysis*

During the 1879-81 triennium, the overall level of pre-reproductive mortality at the patio level of analysis stood at 19.87 per 1000. After adjusting for the

Table 4. Summary of stepwise regression for analysis of district variation in pre-reproductive mortality during periods of 'low' and 'high' ecological stress

Pre-Reproductive Mortality for 1879-81: Dependent Variable					
Variable(s) Entered on Step Number 1. Potable Water					
$F = 11.44218$		Sig. $F = 0.0027$			
		Adjusted $R^2 = 0.31225$			
Variables in the Equation					
Variable	B	SE B	β	T	Sig. T
Potable water	-0.037873	0.011196	-0.584934	-3.383	0.0027
Intercept	34.974770	4.194542		8.338	0.0000
Pre-Reproductive Mortality for 1878: Dependent Variable					
Variable(s) Entered on Step Number 1. % Servants					
$F = 21.05497$		Sig. $F = 0.0001$			
		Adjusted $R^2 = 0.46580$			
Variables in the Equation					
Variable	B	SE B	β	T	Sig. T
% Servants	-0.965811	0.210482	-0.699303	-4.589	0.0001
Intercept	42.324990	4.943941		8.561	0.0000

Variables included in the analysis included initially area, yards per person, median house size, sanitary water, percentage migrant, percentage Jews, percentage servants and gallons of water per person.

Table 5. Multiple classification analysis of pre-reproductive mortality by number of household units occupying a dwelling structure and respective covariates for 1879-81

Source of variation	F	df	Sig. of F
<i>Covariates</i>			
% servants	1.688	1	0.194
Gallons per person	6.290	1	0.012
Wells	0.121	1	0.729
Total number in dwelling unit	0.027	1	0.870
% of extended/multiple families	1.669	1	0.197
Average age of residents	0.349	1	0.855
<i>Main effects</i>			
N of household units	1.384	1	0.219
Explained	1.685	618	0.066
Pre-Reproductive Mortality			
Grand mean = 19.871/1000 under the age of 15			
N of households	N	Unadjusted deviation	Adjusted deviation
1	181	-7.35	-6.56
2	97	-7.95	-9.96
3	72	0.58	-0.77
4	46	9.96	8.09
5	45	13.99	12.43
6	27	14.47	13.28
7+	163	3.57	5.64
Multiple R = 0.178			

effects of the defined covariates, MCA revealed no significant relationship between the magnitude of pre-reproductive mortality and the number of the number of families co-residing in the dwelling unit (see Table 5). While the results proved to be insignificant it is interesting to note that patios of two households showed a lower mortality profile than that of single or large households. The only significant covariate in the defined array was that of the number of gallons of drinking water per person.

During the year of high ecological stress, 1878, the overall level of pre-reproductive mortality at the patio level of analysis rose to 28.03 per 1000. The disparity in the level of mortality for the two time periods at the patio level was comparable to that at the district level. As Table 6 indicates the relationship between pre-reproductive mortality and the number of families in the dwelling unit proved to be border-

Table 6. Multiple classification analysis of pre-reproductive mortality by number of household units occupying a dwelling structure and respective covariates for 1878

Source of variation	F	df	Sig. of F
<i>Covariates</i>			
% servants	0.523	1	0.470
Gallons per person	2.703	1	0.101
Wells	1.669	1	0.197
Total number in dwelling unit	0.365	1	0.546
% of extended/multiple families	0.277	1	0.599
Average age of dwelling unit	4.916	1	0.027
<i>Main effects</i>			
Number of families	2.118	6	0.050
Explained	2.080	618	0.16
Pre-Reproductive Mortality			
Grand mean = 28.028/1000 under the age of 15			
N of households	N	Unadjusted deviation	Adjusted deviation
1	181	-10.81	-11.58
2	97	-19.09	-22.59
3	72	13.64	12.63
4	46	16.72	12.33
5	45	25.07	21.72
6	27	13.40	12.00
7+	163	3.48	9.26
Multiple R = 0.197			

line significant after controlling for the effects of the defined covariates. The pattern of childhood mortality and patio configuration indicates that again dwelling units with 2 households experienced a lower rate of childhood mortality than single family units. Specifically, two family patios had a pre-reproductive mortality rate of 22.59 below the grand mean while single family units stood at 11.58 below the grand mean of 28.03 per 1000. Patios of three or more households displayed substantially higher mortality rates relative to the overall mean with mortality rates peaking at dwelling units of five families.

While the results are far from unequivocal, it appears that two family patios units, not single family dwelling units, had the lowest level of pre-reproductive mortality. It will be argued that such small close-knit families co-residing in the high density urban environ of Gibraltar may have provided the optimal support system particularly in times of high ecological stress.

DISCUSSION

It is a well established fact that contaminated drinking water coupled with poor hygiene and sanitation contribute to high rates of diarrhea among the young [31-34]. The amount of water at the disposal of the civilian population of Gibraltar was at the best of times marginally adequate but during periods of scarcity it fell far short of what would be considered the barest of necessity for the ordinary maintenance of personal cleanliness. But it was not just a matter of quantity that increased the scope for water-induced mortality differentials, the ease of contamination, its relatively high cost, the difficulty in its distribution and the highly localized nature of the water-support system all contributed to high risk. In an area where rainfall was the principal source of water, families that had ready access to stored water during long periods of drought were at a clear health advantage compared to those who did not have a regular supply of potable water. However, it would be a gross over-simplification of the complexity to equate good health with large water tank capacity. Water tank capacity was highly correlated to a variety of other factors that potentially could enhance or detract from health. The complex web of overcrowding, low income, poor sanitation, and low levels of water support system and malnutrition acted synergetically to further increase the magnitude and scope of pre-reproductive mortality differentials.

The patio system of living with its highly localized set of resources could be seen, under one set of circumstances, as potentially health enhancing. Important resources such as water and sanitation could be properly managed and in turn, these communal resources would provide a relatively safe micro-niche where several families could co-exist in relative harmony. The patio system functioned also as an important network and support system in the often

impersonal urban environment in which the economically distressed or ill could gain assistance from an expanded social network that went beyond immediate kin. However, there were limits on just how much real advantage there was in communal living when the separate families lacking a spirit of cooperation and responsibility were compelled to reside in unsanitary domestic environments and substandard housing. Just such an observation was made by Gibraltar's Medical Officer of Health when he stated,

In private houses occupied by just one family, who presumably jealously guard the purity of their drinking water, the connection of the terraces is not likely to affect the health of the community at large. The case is, however, very different in dealing with tenements let out to separate families. It is a matter of common experience, that, where separate families have conjoint responsibility in maintaining the cleanliness of common stairs, courtyards, terraces, etc, there especially will be an unsatisfactory state of affairs to be found [35].

Whether the adaptive potential of patio living was realized or not was dependent on a host of factors, the least of which was the size, membership, location, ownership of the tenement building and the nature of its resources. Communal responsibility for capturing and maintaining a regular supply of water as well as implementation of local knowledge to ensure the water held was safe and pure were some of many other critical factors of the equation of health.

Given the unpredictable nature of rainfall, periodic shortages of water not only represented a threat to health and hygiene but was also a constant source of anxiety to the locals. When water was not available from local storage tanks, water would have to be purchased. The Medical authorities in 1884 examined the quality of water imported from La Linea and found that the well water was highly contaminated [36]. It was also noted that water used from this source was associated with an elevated occurrence of 'high fevers' among those families who relied on this water for drinking purposes. In the case of upper portions of the town where water would have to be carried up the steep winding steps by hand the price of potable water was "often double and never less than $\frac{1}{3}$ more than on the lower levels" [37]. Not surprisingly, it was the poor who were at the greatest disadvantage when it came to obtaining water in the summer months. Without tenant rights and lacking sufficient funds necessary to build expensive water holding tanks or sink wells, the working class and poor were solely dependent on rainfall for their drinking and sanitary water.

The importance of water was not confined to the civilian inhabitants, as water was rationed according to rank, age and sex among the military. In fact, the water situation was such that the military population stationed at Gibraltar was placed at all times on a water allowance just as if the garrison was in a state of siege.

Despite the importance of maintaining a regular and pure supply of drinking water, not every patio

unit took advantage of the water that was potentially available. Roberts, observed for example that in one house in the upper part of the town [House No. 10, District no. 25], "there is a large tank upon the premises, apparently in good condition, capable of holding 41,000 gallons of water, but it is never filled" [17]. This observation is particularly important as the measure of potable water available was based on the holding tank capacity and therefore the proxy measure of drinking water may not have been capturing the actual range of variation. Moreover, the fact that some families of particular patios did not fully exploit the important resource adds to the possibility that differential mortality occurred through a dysfunctional communal support system.

The fact that contamination of private water tanks was commonplace during the study period provides yet another opportunity for differential mortality to occur at the residential level. In the absence of any effective sanitary control over the water supply, health officials could only caution the public that tank water should be boiled before drinking. Familial or patio-based implementation of any sanitary or hygienic principles related to local water resources took on added importance in light of the fact that approximately one-quarter of the population could neither read or write [38]. It was common knowledge that lowering a basket containing lime and charcoal into a polluted tank would often improve the quality of the water [39]. Another method of purifying water was the practise of throwing live eels into the water tank. Besides removing the animalculi in the tank, after attaining a suitable size they were in turn a source of food [6]. Differential implementation of such 'local knowledge', coupled with other elementary aspects of public hygiene (for example, keeping the water collecting area of the roof or terrace free of organic pollutants) led to marked differences in the quality of the water supply from patio to patio and in turn to mortality due to water-borne infections.

When rainwater was wholly insufficient to meet the minimal requirements of the community and the long-standing tradition of water conservation proved ineffective, the population was subjected to a period of high ecological stress. Pre-reproductive mortality rates increased from their normal high rate to excessive levels. While the scarcity of rainfall threatened the health of the entire populous, it was the children of the poor and working classes who were placed at the most immediate and highest risk. Survivorship was now clearly dependent on capital. As the water supply dwindled, the price escalated. It was the wealthy who could retain a firm hold on this first necessity of life. Limited funds of the poor would be diverted away from the only flexible budgetary item—food.

While the source of differential mortality among the young is complex and varied, the economic disparity between the poor and the wealthy was at the very nucleus of the health inequalities observed in

times of high ecological stress. One important manifestation of the gap in wealth was the differences in the nutritional profile of Gibraltar's inhabitants. This was particularly true during the 1870s and 1880s when the population was faced with a depression in maritime trade. For Gibraltar the economic fortunes of its inhabitants rose and fell with barometric regularity with the amount of trade conducted. Poverty became even more pronounced with a general depression in the trade and general inactivity in all branches of commerce. In the absence of a Poor Law or any government-sponsored welfare system, Gibraltar's unemployed and poor were forced to rely on assistance from voluntary charitable organizations or from support from their patio co-residents.

While the nutritional status of Gibraltarians at this time remains largely unknown, a few salient observations can be made. In addition to rent and the price of water, a significant component in the high cost of living in Gibraltar was the price of food as all foodstuffs had to be imported from Spain and Morocco. Given the transportation facilities of the day, the distances involved and the widespread occurrence of monopolies the cost of fresh food could be prohibitive. The Gibraltar Directory of 1877 reports that fruits and vegetables were abundant and that there was a reasonable supply of fish [40]. Immense quantities of poultry and eggs were imported into the garrison town from Morocco. Fresh meat was difficult to come by and commanded a high price owing to importation costs.

Relative to the wealthy Gibraltarian, the poor were at a disadvantage nutritionally as they had lower purchasing power, less free time and were less likely to travel great distances to secure provisions. In the main, the poor purchased their food from small neighbourhood shops. With little competition and a captive market, local shops in the upper and middle portions of the town offered less food choice and charged higher prices than those in the lower portions of the town. The diet of among the lower orders of the population was said to consist of "fish, especially salted and dried, pork in its fresh and salted state, macaroni, rice, oil, bread and a large proportion of the leguminous and other vegetables" [6]. The scope for nutritional inequalities was large even among the working classes given Gibraltar's rigid wage structure and the fact that few married women worked outside the home. In 1878, the wages of the domestics and labourers were about one-third and one-half respectively, to those in the trades [41].

The price and quality of food could vary greatly from shop to shop in the absence of any effective sanitary bye-laws. Many of the bakeries, devoid of any regulation or licensing, were in a disgraceful and filthy state. The use of mules in the kneading of the dough was often cited as a major contributing factor in this regard. The nature of localized health risks and the linkage between water and malnutrition can be appreciated after an inspection of

a house in the upper part of the city (District 26) revealed that,

The portion of the premises used as a bakery is kept in a very dirty condition. . . . The water used in making bread is sanitary water, stored in a dirty tank. Except in case of actual difficulty in obtaining a sufficient quantity of fresh water, I consider that sanitary water should not be used for this purpose. Although organic matter of a dangerous character is likely to be destroyed during the process of baking, a quantity of salts liable to cause dyspepsia and diarrhea will remain in the bread [42].

Equally distressing was that food declared unwholesome by the authorities was only later to be reintroduced in a clandestine manner into the town for consumption among the poor.

The quality and cost of milk was an important aspect of the nutritional profile of Gibraltar's children. During the study period, Gibraltar's milk supply was more or less devoid of sanitary control and therefore constituted a serious health risk to young children. The majority of milk consumed in Gibraltar came from southern Spain where the milking, storage and transportation of milk was outside the control of local authorities. Two kinds of milk was sold either in small local shops or through street vendors the 'leche pura' and 'leche con agua'. The latter was typically half the cost but frequently contained up to 60% water, which came from a surface well of dubious quality located in the town of La Linea. Adulteration of the milk with water, at times up to 35–40%, was commonplace throughout 19th-century Gibraltar. A survey of 15 samples of milk taken in 1892, for example, found that only 4 were unadulterated [43]. Control over the quality of the milk supply was further complicated by the fact that the majority of the street vendors were young boys aged 12–15 who were less liable to be convicted if caught. Even if the milk was purchased 'pure', it was not unusual to find milk stored and boiled in dirty rooms and patios as well as placed in the proximity of water closets. As was the case with water, the quality and storage of milk could vary from patio to patio and such conditions could set up the opportunity for mortality differentials to occur at the smallest scale, the household. The quality of milk supply remained a problem well into the 20th century and a source of malnutrition among Gibraltar's young.

CONCLUSION

The results indicate that depending on residential location and the amount of annual rainfall Gibraltar's civilian inhabitants experienced distinctive mortality profiles. Gibraltar's urban landscape *ca* 1878 was the product of a number of socio-geographic factors; namely, limited opportunity for geographic expansion, an inhospitable terrain and competing military and civilian interests. Under normal rainfall conditions, there existed both at the inter-district and patio level considerable variation in the magnitude

and scope of pre-reproductive mortality. The potential for high mortality was greatly magnified as the result of residence in a city with an unusual combination of features, that is an international port, a military fortress and an important commercial city at the tip of the Iberian peninsula. The imposition of colonial and military rule that was often unsympathetic and unresponsive to the needs of the indigenous population provided yet another window of opportunity for high mortality. Substandard housing, the dearth of byelaws regarding the food supply and sanitation, grossly over-crowded buildings, and the absence of effective health care and medical services for the young jointly contributed to the final tier of a platform of high risk to illness. Collectively these factors not only produced a population with an unusual medical history and a distinctive world view but it also created a bio-social milieu in which the disease exposure potential of the community was magnified well beyond mere size alone.

For some families communal living and a highly localized resource base effectively buffered the young from the hostile environment. For the less fortunate, communal living under the patio system intensified the health risks associated with urban living and subjected the young to a continuous stream of environmental insults that ultimately diminished their chances of survival. In the final analysis, it was the decentralized nature of vital resources, such as water and food, and marked economic inequalities between the various housing units that ultimately played an important role in maximizing the opportunity for differences in mortality to accrue at the level of the district and patio level.

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