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Rainfall, Patio Living, and Crisis Mortality in a Small-Scale Society: The Benefits of a Tradition of Scarcity?[1]

L. A. SAWCHUK
Department of Anthropology, Scarborough Campus, University of Toronto, Scarborough, Ont., Canada M1C 1A4. 18 XII 95

Crisis mortality—the sudden and dramatic increase in the death rate arising from a common, unusual causal factor operating for a limited period of time (Bouckaert 1989)—can directly and indirectly modify other demographic parameters of large populations (e.g., reproduction, marriage, and migration) as well as affecting their genetic and cultural continuity. For isolated small-scale communities, crisis mortality can have similar effects and in extreme cases can result in extinction (see, e.g., Cook 1973, Laughlin and Brady 1978, McNeill 1976, Dobyns 1993). Despite the interest in crisis mortality, there is a dearth of studies that explore intracommunity responses under crisis conditions (see e.g., Wrigley and Schofield 1981, Palloni 1990, Lechat 1990, Yach, Mathews, and Buch 1990). This study focuses on a historical population which represents for all intents and purposes a unique human laboratory setting. Opportunistically exploiting the unusual features of this community yields insight into the different ways in which segments of a community respond to crisis mortality.

The setting is 19th-century Gibraltar, where substandard housing, the absence of sanitary and food-quality bylaws, grossly overcrowded buildings, and ineffective health care and medical services collectively contributed to a pattern of high background mortality (Sawchuk 1993)—a uniformly high death rate among the young due to the continuous action of infectious disease, malnutrition, and the synergism between them. Many of the same features are still found in developing countries today. The potential for episodic mortality triggered by infectious epidemics was high because of Gibraltar's status as port city, garrison town, and important commercial centre. The devastating effects of epidemics of yellow fever (1804 and 1828) and cholera (1834 and 1865) bear witness to the deadly potential of infectious disease as a source of crisis mortality (Benady 1994). This study focuses on another facet of Gibraltar's unusual character to illustrate the consequences of crisis mortality arising not from an epidemic but from unusually low rainfall. Gibraltar is singular in that until 1885 its inhabitants relied totally on harvesting rainfall for their drinking water. Since British occupation of the Rock in 1704, Gibraltarians have literally been at the mercy of local rainfall conditions, for, unlike most urban centres, which lie close to rivers and streams, the Rock has no natural source of potable water. By the 1870s Gibraltar had developed a highly decentralised water supply, one in which some residents had access to a well and/or a cistern while others did not. Not only did water availability vary from building to building, but in the absence of any local ordinances regarding the sanitary condition of the water tank, the purity of the drinking water varied from patio to patio. There is evidence that some patios used the technique of lowering a basket containing lime and charcoal into the tank to improve water quality, while others used live eels to remove animaliculi in the tank. Still others ignored such practices and failed even to keep the water-collecting area of the roof or terrace free of organic pollutants (Sawchuk 1993). The unsanitary nature of the construction and position of water tanks was of serious concern to Gibraltar's medical officers (MacPherson 1890:21):

> Whatever may be the impurities arising from the collecting area, they are nothing when compared with those that are liable to occur from the position of the tank itself. Placed, as I have constantly seen it, with unprotected covering, under dirty bedrooms, greasy kitchens, filthy storerooms, patios, shops and public passages and often surrounded on all sides by defective drains, placed in such a position, it must be considered one of the gravest sanitary defects here, and one of the chief channels, by which enteric fever, cholera and many less apparent and milder diseases are propagated.

This study exploits this feature of variation in water accessibility at the building level and focuses on how well people fared in four ecologically sensitive housing groupings. Table 1 shows that in 1878 the majority of Gibraltarians did not live in single-family dwellings, instead residing in large multilevel tenements or patios. Accommodating on average three to four families and numbering some 20 individuals or so, a patio would have a common entrance way, shared laundry facilities and watercloset(s), and sometimes a cistern and/or a well. There was a clear association between wealth (as measured by the presence of servants in the household) and the availability of water at the patio level. Patio size and household size showed significant group variation ($F = 3.42, p = .017$ and $F = 3.65, p = .012$, respectively). A Student-Newman-Keuls test revealed that the only post-hoc group difference in possible crowding was between patios with both cisterns and wells and patios with cisterns only.

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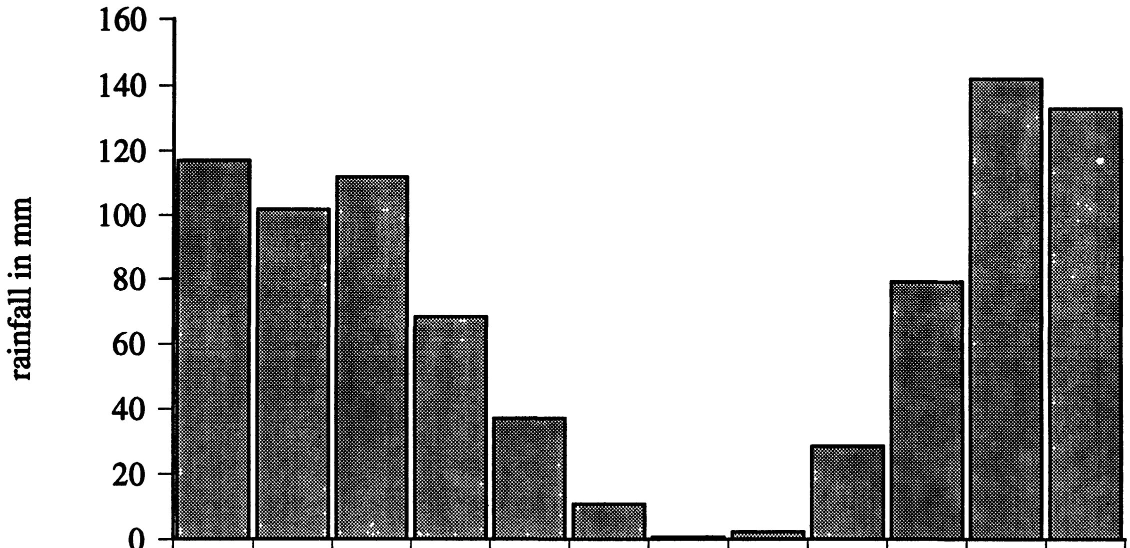
TABLE 1
Patio Housing and Water Facilities in Gibraltar ca. 1878

	Housing					
Water Facilities	Number of Houses	% of Total Population	% of Buildings Occupied by One Family	Average Number of Residents per Patio	Average Household Size	% of Households with Servant
None	89	12.39	3.78	19.57	4.56	14.39
Cistern	304	54.3	2.83	25.12	5.43	25.11
Well	75	10.48	10.71	19.64	4.4	34.88
Cistern and well	167	22.83	11.5	19.23	3.84	54.49

NOTE: Population 14,061, excluding residents of the South, the North Front, and Catalan Bay.

Meteorological information collected for the period 1860 to 1959 served as the benchmark for the "normal" pattern of rainfall. Figure 1 shows that, like most of the Iberian peninsula (Wallen 1970), Gibraltar receives most of its rainfall in the cold half of the year (winter and autumn). After the rains of November to May there is a long drought lasting from June to August. During the summer, drinking water had to be obtained from private underground storage tanks or purchased from the highly polluted wells in the nearby Spanish town of La Linea (Staples 1885). Unsupervised and untrained in cleanliness, hawkers would sell water carried in unsterilized wooden barrels by mule. While residents could obtain water from local wells, such water was normally used for sanitary purposes, as it was brackish and highly charged with organic matter. Under drought conditions, the population had to rely increasingly on a less than safe and pure water supply. For example, Gibraltar's medical officer observed that in one bakery, sanitary water stored in a dirty tank was used in the making of bread: "Except in the case of actual difficulty of obtaining 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" (MacPherson 1892). The quality of the food supply was also compromised by the adulteration of milk and the addition of contaminated water to the milk supply. The use of contaminated water affected the quality of such food staples as bread and milk, a critical element in the diet of children who are in the process of being weaned from the breast.

Figure 2 shows that there was considerable variation



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	116.9	101.8	111.8	68.2	37	10.9	0.7	2.3	28.5	79.1	141.9	132.9
C.V.	79.6	84.6	69.3	73	91	187.7	331.3	231.2	135.6	77.5	76.8	88.4

FIG. 1. *Average monthly rainfall in Gibraltar, 1860–1959.* C. V., *coefficient of variation.*

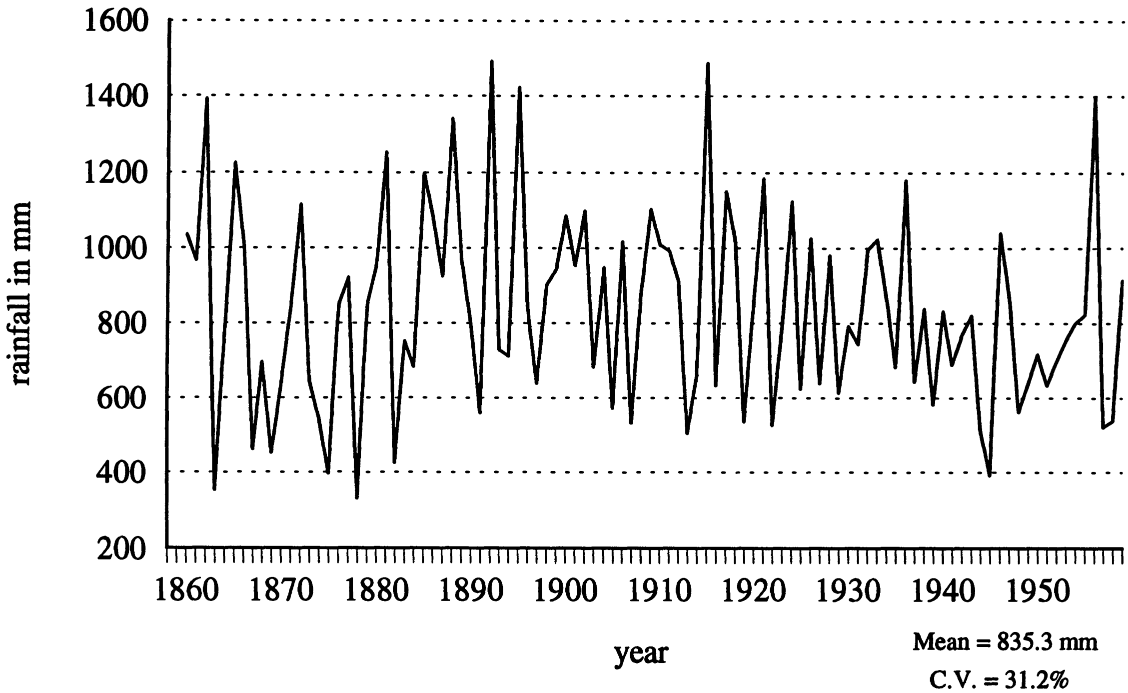


FIG. 2. *Total annual rainfall in Gibraltar, 1860–1959 (cumulative total measured from September of one year through August of the next).* C.V., *coefficient of variation.*

in annual rainfall and, on occasion, marked shortfalls. Between 1873 and 1884, for example, three years (1875, 1878, and 1882) were identified as having unusually low rainfall (below 50% of the century norm) and were pooled as representing high ecological stress. The remaining years were viewed as normative and grouped as representing low ecological stress.

To evaluate the health status of residents of each of the four residential units, life expectancies were computed and compared following the methodology of Chiang (1984) using LifePro, a computerised lifetable program (Sawchuk and Anthony 1989). The population at risk for each group was reconstituted from an analysis of the 1878 nominative census rolls. A housing survey conducted by the colonial government in 1879 provided detailed house-by-house information on the nature of water amenities for each of the 635 patio units in the town of Gibraltar. The under-one-year age-group warranted special attention and was computed by linking each birth to a birthplace as shown in the compulsory government birth registers. Cause-specific death information by age and residence at time of death was similarly extracted from the death registers. Following the rationale outlined by Sawchuk, Herring, and Waks (1985), deaths attributable to the diarrhea complex (gastro-enteritis and diarrhea), the pneumonia/bronchitis complex, and the nutritional complex (marasmus, anaemia, and starvation) were combined into a single category, termed weaning diarrhea. Weaning diarrhea is the product of synergy between enteric infections, malnutrition, and repeated insults from infectious disease (see, for example, Mortarjemi et al. 1993). Weaning diarrhea is influenced by the timing of the cessation of breast feeding, and, accordingly, the risk of weaning-diarrhea mortality is population-specific, ranging from three months to approximately three years of age. In the case of 19th-century Gibraltar, biometric analysis of the pattern of infant mortality (Bourgeois-Pichat 1951) suggests that weaning typically took place after six months of age. Since an impure and insufficient supply of water would facilitate an increase in deaths due to weaning diarrhea, the death rate attributable to this complex is used as a proxy measure of the impact of high ecological stress on the health of a population.

When ecological stress was low, the only residential group that enjoyed a statistically significant overall advantage in life expectancies during childhood was the one with access to both cistern and well water (see tables 2 and 3). The mortality rate attributable to weaning diarrhea shows a strong inverse relationship with the availability of patio-based water resources (fig. 3). These findings are consistent with the results of other studies showing the importance of water availability in determining health status (VanDerslice, Popkin, and Briscoe 1994, Moe et al. 1991). Under high ecological stress, however, the economically derived mortality differential disappeared. Residents lacking water resources fared better than the groups with water resources, showing smaller declines in life expectancy, and were the only group that did not undergo a significant rise in the death rate attributable to weaning diarrhea.

The lesser impact of high ecological stress on the health of residents lacking communal water facilities can be attributed to a higher degree of adaptability based

TABLE 2
Childhood Life Expectancy by Patio Water Supply and Degree of Ecological Stress

	Degree of Ecological Stress							
	Low				High			
Patio Water Supply	Under 1	1–2	3–5	*n* Deaths	Under 1	1–2	3–5	*n* Deaths
None	43.92 (1.77)	52.47 (1.72)	57.59 (1.56)	262	40.68 (3.07)	49.43 (3.11)	57.62 (2.79)	93
Cistern	47.49 (0.8)	53.94 (0.75)	57.07 (0.71)	225	34.7 (2.67)	43.66 (2.73)	48.57 (2.37)	104
Well	46.36 (1.9)	51.75 (1.82)	54.8 (1.58)	1,030	35.02 (3.16)	44.54 (3.27)	49.3 (2.9)	492
Cistern and well	53.86 (1.3)	58.28 (1.2)	60.92 (1.1)	343	40.49 (2.07)	48.75 (1.92)	52.83 (1.71)	202

NOTE: Numbers in parentheses are standard errors.

in part on a long-standing tradition of coping with scarcity. It is possible that this tradition was grounded in a communal strategy whereby patio members displayed enhanced communication, group solidarity, neighbourly help, and shared care of the young—social characteristics that collectively were health-enhancing and provided a buffer against the environment (for theoretical discussion see, e.g., Berkman 1984, Janes 1990). Gibraltar's medical officers observed that a highly decentralised water supply not only inhibited the spread of communitywide epidemics but also restricted the occurrence of outbreaks to individual patio units (MacPherson 1890). Using contemporary information from four population-based prevalence studies among preschool-age children, Katz and co-workers (1993) found that both household-specific and community-level factors play an important role in diarrhea transmission and disease clustering within households and villages.

It can be assumed that patios that depended on an external water supply during the summer months had long experience with the use and treatment of impure water. The continual shortage of water among these groups also stimulated the development of sanitary measures that relied less on water for the treatment of excreta and other solid wastes. Finally, patios dependent on a contaminated water supply may have developed a higher degree of natural immunity because of repeated low-level or asymptomatic exposures to enteropathogens and subsequent illnesses during early childhood.

In conclusion, the long-standing tradition of coping with water scarcity and a history of greater pathogen exposure proved particularly advantageous under high ecological stress among residents lacking permanent water facilities, as it provided them with a broader spectrum of adaptability to rapid changes in the local environment.

TABLE 3
Comparison of Childhood Life Expectancies with Different Water Resources and Degrees of Ecological Stress (t-Test)

	Degree of Ecological Stress					
	Low			High		
Patio Water Supply	Under 1	1–2	3–5	Under 1	1–2	3–5
Cistern and well vs. None	4.53**	2.76**	1.74	−0.05	−0.19	−1.46
Cistern and well vs. Cistern	4.17**	3.06**	2.94*	1.72	1.53	1.45
Cistern and well vs. Well	3.26**	2.99**	3.17**	1.44	1.11	1.05

** Significant at .01 or better.
* Significant at .05 or better.

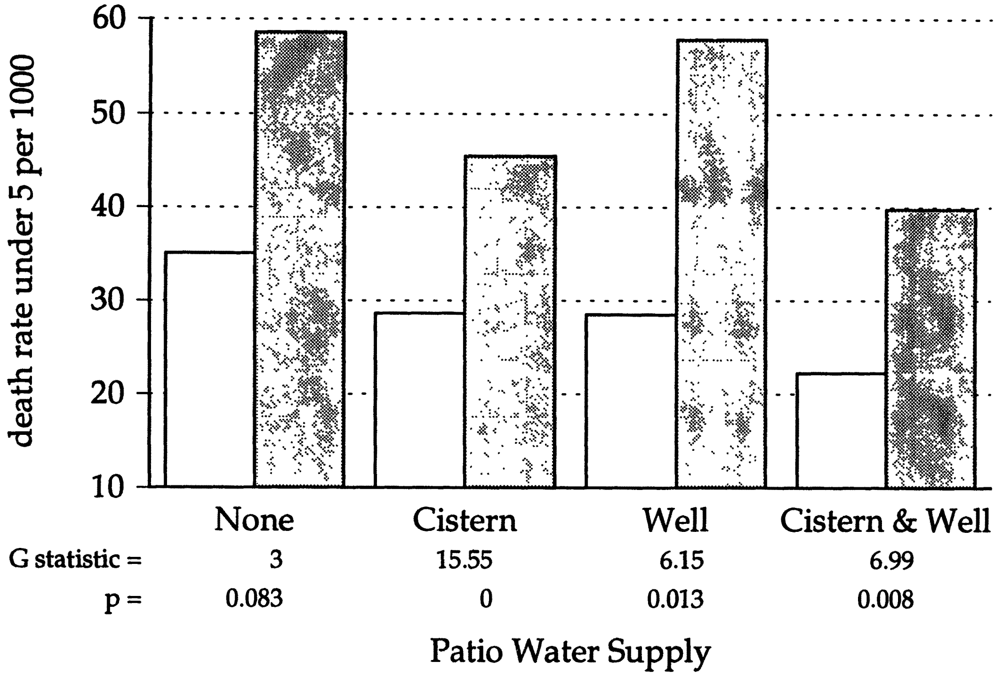


FIG. 3. *Childhood mortality rate due to weaning diarrhea and patio water supply under low* (white bars) *and high* (stippled bars) *ecological stress in Gibraltar, 1873–84.*

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