# DISASTER AT A DISTANCE: MORTALITY CONSEQUENCES OF THE 1815 TAMBORA VOLCANIC ERUPTION ON RURAL ITALIAN TOWNS

**by**
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## INTRODUCTION

In April 1815, one of the largest known volcanic eruptions occurred at Tambora on the island of Sumbawa, Indonesia (Simkin, 1994).[1] It is estimated that 10,000 people were killed instantly (Sigurdsson and Lovelace, 2006; Evans, 2002), and 88,000 people died overall from the eruption on the islands of Sumbawa and neighboring Lombock (Stothers, 1984). The great quantities of magma and ash fallout from this eruption created global climate anomalies, which had farther ranging demographic consequences than the areas immediately surrounding the volcano. The volcanic dust from the Tambora eruption blanketed much of Europe and North America during the summer of 1816 and caused the below-normal daily temperatures known as the "Year Without a Summer" (Oppenheimer, 2003). This moniker is a telling description of the climate conditions that Europe and northeastern North America experienced in 1816 (Simkin, 1994).

Previous research on this period (1810-1820) has focused on the causes of the extreme climatological conditions of 1816 and the resulting environmental destruction. However, little research has focused on the demographic consequences of these conditions, particularly for rural regions further away from the eruption site. This paper is a first step in filling in the research gap. I use summary administrative records for 32 towns in the Sulmona District of the Abruzzi region of Italy to examine correlations between mortality events and the sudden global cooling of the "Year Without a Summer." This paper has two major contributions for the field of historical demography. The first is that it uses two sources of data not previously available widely. One of these data sources is aggregate level data for 32 towns previously only available in the state archive in L'Aquila, Italy on paper. The second source of data is individual-level death records for nine of these 32 towns transcribed from the microfilmed individual records available at the Family History Center Library in Salt Lake City, UT. Together, these two datasets provide a fuller demographic context of rural Italy in the early 1800s. The second contribution of this paper is to support the broader mortality impacts of the 1815 Tambora eruption.

## DATA SOURCES

The primary data for this paper come from the civil registration system, which began about 1810 when many parts of Italy came under the control of the Napoleonic Code.[2] The data on deaths examined in this paper came from two sources. Summarized population data for the 32 towns in the Sulmona District are located in the Archivio di Stato in L'Aquila (A. S. Aq.) for 1810 to 1859. I transcribed the data for these 32 towns into a database for analysis and evaluated the deaths for the period 1810 to 1829. In addition, the individual death records have been microfilmed and are available in the United States at the Family History Center's Library in Salt Lake City, UT.[3] I chose nine of the

[1] For more details regarding the Tambora eruption, see Siebert and Simkin (2002- ).

[2] Before 1809, the Roman Catholic Church kept many of the earliest vital records. The Napoleonic Code is a system of laws based on Roman law that Napoleon originally instituted in France and subsequently applied to his conquered territories. Book I, Title II, Chapter II of the Napoleonic Code focuses on Acts of Births and the first item states that "Declarations of birth shall be made within three days after delivery, to the civil officer of the place: the child shall be shown to him." Chapter III is entitled "Of Acts of Marriage", while Chapter IV is entitled "Of Acts of Decease." (http://www.napoleon-series.org/research/government/c_code.html#book1)

[3] The catalog for the library is available on the internet, http://www.familysearch.org/eng/Library/FHLC/frameset_fhlc.asp.

32 towns in the Sulmona District to transcribe the individual records from microfilm, analyze and evaluate in more detail these records for the period 1809 to 1829.[4] To measure the climatic instability in the period, I used Lamb's work (1970, 1977, and 1983), particularly his 1970 publication. In these publications, he documents the calculation of an index for volcanic dust in the atmosphere, i.e., the Dust Veil Index (DVI). The purpose of this index was to

> ...quantify the impact on the Earth's energy balance of changes in atmospheric composition due to explosive volcanic eruptions. The DVI is a numerical index that quantifies the impact of a particular volcanic eruptions [sic] release of dust and aerosols over the years following the event. (Lamb, 1985).

Volcanic releases of dust and aerosols have been shown to generate significant climatic changes by obscuring "solar radiation from reaching the Earth's surface" (Simkin, 1994: 913).

## METHODOLOGY

To examine the mortality consequences of the 1815 Tambora eruption, I use summary administrative records for the 32 towns in the Sulmona District of the Abruzzi region of Italy, and individual-level data for six of these 32 towns during the 1810s, a period that includes the "Year Without a Summer." As a first step in determining the relationship between environmental changes and mortality, correlation coefficients are calculated between the annual DVI as a proxy for sudden global cooling and registered deaths for the 32 towns for each year. I hypothesize that there will be a lag between the initial increase in DVI in 1816 and increases in the number of deaths: crop failures in 1816 led to famine and increased mortality in the following year (Stothers, 1984).[5]

The next step in the evaluation accounts for the underlying trend and overcomes the problem of population size differences among the 32 towns.[6] A Z-score is calculated for each town for each year from 1810 to 1829 using the equation:

$$Z - score = \frac{E - \overline{E}}{\sigma}$$

E designates the observed number of registered deaths for the particular year, $\overline{E}$ is the mean annual number of registered deaths, and $\sigma$ is the standard deviation of the number of registered deaths

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[4] The nine towns selected are: Anversa (Anversa (L'Aquila), 1979); Barrea (Barrea (L'Aquila), 1979); Bugnara (Bugnara (L'Aquila), 1981); Campo di Giove (Campo di Giove (L'Aquila), 1980); Cansano (Cansano (L'Aquila), 1980); Castrovalva (Castrovalva (L'Aquila), 1979); Introdacqua (Introdacqua (L'Aquila), 1981); Pettorano-sul-Gizio (Pettorano-sul-Gizio (L'Aquila), 1982-83); and Rocca Pia (Rocca Pia (L'Aquila), 1984) – also known as Roccavalleoscura in the 19th century. Initially six towns were chosen for more in-depth evaluation because of their similar characteristics and close geographical proximity to each other. Three more towns were added as the data were collected. Long term, I hope to collect the individual records for all 32 towns in the Sulmona District.

[5] Stothers (1984) states that in 1816 for Europe and North America, "daily temperatures (especially the daily minimums) were in many cases abnormally low from late spring through early fall… Many crops failed to ripen and the poor harvest led to famine, disease, and social distress compounded by the aftermath of the Napoleonic wars." The climatological conditions of 1816 also spawned the last major typhus epidemic in Europe (1816-1818) (Post, 1970; 1976). Oppenheimer (2003:230) states that "Crop failures were widespread and the eruption has been implicated in accelerated emigration from New England and widespread outbreaks of epidemic typhus." This outmigration of population from New England looking for more hospitable climate west of the Ohio River was important for the "… settling of the American heartland" (Evans, 2002). Some say that it was partly because of this outmigration that Indiana and Illinois were able to become states in 1816 and 1818, respectively.

[6] This methodology is consistent with that used by Witham and Oppenheimer (2005), who studied mortality in England during the 1783-4 Laki Crater eruption. Witham and Oppenheimer (2005) based their research methodology on the research techniques in the demographic studies of Charbonneau and Larose (1979) and Dobson (1997).

during the period for each town.[7] Positive Z-scores demonstrate above average registered deaths and negative scores indicate below-average deaths. Consistent with other historical demographic research, we will interpret Z-scores for deaths of greater than 2 to represent a crisis year.[8]

Historically, these rural regions relied upon agriculture for the subsistence of their populations.[9] Since many rural communities were quite isolated with limited transportation, outside food could not be imported to make up the difference if there was a shortfall in local harvests. The timing of the long cold snap, "coincided with the June-to-September growing season" of 1816 (Evans, 2002) and thus seriously reduced the ability of many rural communities to sustain themselves through to the next harvest. People either died or left the community, putting the social stability of such rural communities at risk.[10] Thus an examination of the seasonality of deaths within each year, as well as the age distribution of deaths is important. To account for these patterns, the next step of the analysis focuses on the nine towns in the Sulmona District. To examine seasonality patterns, I use individual-level records to calculate Z-scores of monthly totals of registered deaths. The monthly Z-scores will give an indication of which months contributed most to the mortality crisis of 1817. Since the number of deaths occurring within a month in the 19th century varies naturally and significantly by season this is an important demographic quantity to know.[11]

Patterns of age distribution of death using broad age categories are examined using annual individual level data. Age at death was listed on the death certificate. In order to minimize possible age misreporting I use the following age categories: less than 1 year; 1 to 4 years; 5 to 14 years; 15 to 44 years; 45 to 64 years and 65 or more years.[12]

## SUMMARY AND DISCUSSION

Political instability during the 1810s had important consequences for all of Italy. However, the geographic isolation of the Aquila province and its historical reliance upon agriculture for the subsistence of its population meant that climatic instability, rather than political instability, likely had greater impacts on mortality for the communities in the Sulmona District.

The volcanic eruption of Tambora in 1815 is documented as one of the largest known eruptions, yet the demographic impact of this eruption has only been judged with regards to its local impact on the population in Indonesia. Research on volcanic air pollution connects huge quantities of magma and ash fallout to global climate anomalies, which could have far- ranging consequences for populations distant from the volcano. This paper begins to examine distant demographic impacts by

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[7] Analysis was undertaken to examine the sensitivity of the results through including and excluding the 1817 data in calculating the average and standard deviation. In general, economists would tend to include the outlier year in this calculation. However, by not including the events of 1817, the magnitude of the events of 1817 would be made more visible. In this research, the year 1817 was included in the calculation of the average and standard deviation.

[8] This is consistent with the "mortality crisis" definition used by Witham and Oppenheimer (2005), who based their definition on the work of Wrigley and Schofield (1989) and Dobson (1997).

[9] Bell (1979: 8) wrote that variations in physical features such as altitude, climate, soil conditions and physical accessibility (to name a few), "affect every aspect of rural Italians' lives and cause discernible fluctuations in rates of birth, marriage, and death."

[10] Out-migration will not be examined in this paper, but data show that the number of out-migrants from the 32 towns in the Sulmona district was the highest in 1817 compared to the other years between 1810 and 1829.

[11] Civil registration records for the nine towns analyzed have two dates listed. The first date on the form is the date of registration of the event and the second date on the form is the date of the actual occurrence of the event. Preliminary examination of the records in Pettorano-sul-Gizio appear to indicate that the interval between the date of occurrence of the event and the date of registration of the event was usually no more than 1 to 2 days and usually occurred within hours of the event (Author's ongoing research). In this research, the date of occurrence was used to examine seasonality of death.

[12] A preliminary examination of the records from the town of Pettorano-sul-Gizio indicates that the age reported on death certificate is fairly consistent with linked birth record information. Any age differences found between reported age on the death record and calculated age at death from linked birth-death records was less than one year (Author's ongoing research).

examining deaths in 32 towns in rural Italy. The data show that there was an overall mortality crisis in 1817, and that is correlated with the 2-year lagged increase in DVI in the majority of the 32 towns in the Sulmona District. In addition, examining individual-level death records for nine of the 32 towns demonstrates that the mortality crisis occurred specifically between July and December 1817, and impacted all age groups (save infants) of these communities.

While the primary focus of this paper has been on deaths, this is not the only demographic consequence of the sudden climate change caused by the Tambora volcanic eruption of 1815 on rural communities. Deaths are the most extreme reaction to climatic instability. However, migration, births and marriages may also be impacted by climatic instability. Individuals in a rural community, in response to limited resources or economic instability brought about by poor harvests, may adjust to such events by leaving the community (out-migration), delaying marriage if they stay in the community and thus in turn delaying fertility. Climatic instability during the growing season would contribute significantly to an unstable economic environment as described by Stothers (1984) by limiting resources and raising prices of foodstuffs.[13] Preliminary examination of the birth data for these nine towns indicates that fewer births occurred in 1816 and 1817 relative to adjacent years. In addition, since marriage is strongly tied to fertility in this period, a decline in marriages would also decrease the subsequent number of births that occurred.[14]

[13] Although it cannot be examined in this paper because the data are not available, the morbidity of the community could also have been impacted during this time with increased chronic respiratory health problems from the volcanic air pollution (Durand and Grattan, 2001; Grattan, et al., 2003; Pope III and Dockery, 2006). Researchers studying the Laki fissure eruptions (Iceland) in 1783-84 found contemporary descriptions of morbidity such as "headaches, eye irritation, decreased lung function, and asthma" in England and France (Grattan, et al., 2003). In addition to respiratory impacts, there were descriptions of cardiovascular health impacts, as well as general comments of fevers and epidemics. The Laki fissure eruptions (Iceland) in 1783-84, while closer to Europe/Italy, were of a much smaller magnitude than Tambora. Contemporary descriptions (after 1783-84 eruption) from northern Italy found, "A phenomenon of prolonged and very dense fog, which completely hid the sun, and at night made the moon appear reddish and murky. This fog caused, moreover, many illnesses and putrid and acute fevers, so that many people died" (Fajonio, cited in Camuffo and Enzi, 1995). Thus, it is expected that if we were able to find contemporary writings on the morbidity experience during the years following Tambora in the rural communities of the Sulmona district, we would probably find similar descriptions.

[14] Preliminary results from Pettorano-sul-Gizio indicate that there is a link between the demographic events of marriage and births and DVI. The correlation coefficient between DVI and marriages was quite highly negatively correlated without any lag (R=-0.668), while recorded births were best correlated with a 2-year lag (like deaths) to DVI (R=-0.703) (Condon, 2007).

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