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How Many Persons in East Timor Went 'Missing' During the Indonesian Occupation?: Results from Indirect Estimates

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Approved by

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Abstract

Indonesia's occupation of East Timor from 1975 to 1999 caused an unknown number of deaths due to violence and starvation. In the first few years alone casualty estimates range from 60,000 (Houk 1978) to over 300,000 (Defert 1992). Recent statistical work done for the Commission for Reception, Truth and Reconciliation in East Timor (CAVR) concludes that there were at least 102,800 (± 12,000) conflict-related deaths during the period (Silva and Ball 2006). However, this is a conservative estimate. This paper complements the existing estimate by calculating a reasonable high-end estimate, using standard demographic methods of indirect estimation to census data from before, during, and after the Indonesian occupation. My results suggest that a reasonable upper bound on excess deaths during the period is 204,000 (± 51,000). Since technically these are "missing persons" some could have emigrated, been overlooked by a later census, or, in the case of children, not been born. Great care is taken to ensure that these sources of error are minimized as much as possible. Sensitivity tests were conducted on these results using a variety of different assumptions, yielding estimates as low as 100,000 and as high as 360,000. Previous efforts to indirectly compute the "missing" population in East Timor simply extrapolated earlier-period population growth rates in order to surmise the number of missing persons. The estimates computed here are much more sophisticated: they indicate the age and sex distribution behind these totals, and account for changing migration, fertility, and baseline mortality during the period in order to help isolate the population that went missing due to excess mortality alone.

Acknowledgments

About the Author

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How Many Persons in East Timor Went 'Missing' During the Indonesian Occupation?: Results from Indirect Estimates

Sarah Staveteig

Introduction

East Timor, a nation barely larger than the state of Connecticut (USA), captured world attention in 1999 during its historic United Nations-sponsored referendum on independence. The lead-up to the vote was marred by violence for several months, as pro-Indonesian militia killed, threatened, and intimidated the East Timorese population in an effort to keep them from voting for independence. On August 30 of that year, the East Timorese electorate overwhelmingly voted in favor of independence from Indonesia. The vote ended 24 years of Indonesian annexation. Following the elections, in an apparent act of revenge, pro-Indonesian militias killed an estimated 1,000 supporters of independence. One-quarter of a million East Timorese fled to West Timor (Gunn 2000). Looting and ransacking were widespread, and the Indonesian "scorched earth" policy destroyed more than 70 percent of the housing stock in East Timor (Dolan et al. 2004). The events of 1999 were perhaps best described as a "brutal finale" to 24 years of Indonesian occupation (Nixon 2004).

Although much has been written about East Timor since 1999, little is known about the full impact of Indonesian occupation, which began in 1975, following more than 400 years of Portuguese colonial rule. Currently, in the wake of East Timorese independence and the establishment of the Commission for Reception, Truth and Reconciliation in East Timor (CAVR), there is an interest in determining the extent of human rights abuses during the Indonesian occupation. This paper focuses on population-level estimates of "missing persons" from 1975 to 2000.[1] A tally of missing persons includes our topic of interest: the *excess mortality* during the period, that is, the number of deaths above and beyond those that would have been expected under "normal" circumstances. Yet because these estimates of "missing persons" are based on indirect methods, it is impossible to discern whether missing persons died, were not born, emigrated, or were simply not enumerated in a later census. Hence, we cannot label these 204,000 persons "deaths"; we can only state with certainty that our best estimate suggests that they went "missing" between 1975 and 2000. Despite these disadvantages, indirect estimation is an important way to verify the reasonability of existing estimates of excess mortality and to provide a hypothetical upper bound on excess mortality during the period.

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[1] Since population estimates are generally done during mid-year, and the violence in East Timor in 1999 went well into the last months of the year, the missing person count is computed for mid-year 2000.

Estimates of excess mortality cannot, of course, tell the entire story: by definition such figures obscure the richness of individual histories and events. Yet mortality figures are an important way to summarize the experiences of a population, particularly when so many victims and their stories will forever remain unknown. The fact that each person has equal weight in such counts could also be thought of as a "democratic counterbalance" to *ex post* efforts to steer historical attention toward one particular version of events.

Wars and occupations tend to cause indirect mortality in the population above and beyond battlefield deaths (Li and Wen 2005; Ghobarah et al. 2003), particularly if medical systems break down; internal migration causes poor living and sanitary conditions, and food becomes scarce. Excess mortality is difficult to pin down, however, because "missing" persons (who are absent even above and beyond the expected number of deaths) may in fact have emigrated, gone into hiding and been missed by later censuses, or died due to disease or natural causes that would have occurred even in the absence of an armed invasion. Similarly, a large portion of the post-occupation population may well have arrived from outside East Timor—for example, via Indonesia's transmigration program—and thus disguise high levels of wartime mortality among the native population.[2]

Despite these challenges, indirect estimation of mortality is still a critical task for truth commissions, historians, and politicians. The casualties of war are certainly a subset of the number of "missing" persons. When combined with survivor testimonies and other historical evidence of military incursions, consistently high levels of "missing" people are strongly suggestive that Indonesian aggression in East Timor was responsible for a large number of deaths in the population.

In this particular case, robust statistical evidence gathered by the Human Rights Data Group (HRDAG) on behalf of the Commission for Reception, Truth, and Reconciliation in East Timor (Silva and Ball 2006) has estimated that at least 102,800 (± 12,000) East Timorese died of causes related to the Indonesian occupation from 1974 to 1999 [herein referred to as the Silva and Ball estimate]. This result was based on years of painstaking data collection and analysis using a retrospective mortality survey, a graveyard census, and narrative testimonies. Given this well-documented finding, why use indirect estimation at all? First, for a question that is as politically contentious as the number of Timorese who went "missing" during the Indonesian occupation, it is important to see what we can determine from official sources. Critics of the high Timor death toll counts are more likely to trust estimates obtained from the Indonesian's own data, than from non-official sources of information such as those collected by Silva and Ball—however statistically impressive the latter may be. Second, this case is a unique opportunity to compare the validity of indirect to direct methods, because it is one of few cases where both types of data exist. In many situations, it is too expensive, time-consuming, or politically inexpedient to conduct retrospective surveys and gather other forms of independent data. This is not to say that these sources are not important—indeed, they may offer our greatest hope of producing accurate reports of the extent of human rights violations. But if we want to be able to quantify the death toll of historical wars and other difficult-to-access population, indirect methods are important to develop. Third and most important, indirect estimation provides a

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[2] Fortunately post-occupation censuses in East Timor have gathered data on the nativity of the head of household, which allows us to distinguish between native Timorese households and other immigrants. To the extent that there were mixed marriages among natives and immigrants, however, the census data may be misleading.

useful "upper bound" on the total number of East Timorese who died during the Indonesian occupation. This upper bound is a useful complement to the multiple systems estimation and survey methods used by Silva and Ball which provide a "lower bound" of the total number of persons who died of causes related to the occupation.

Why do I claim that Silva and Ball's estimates are a lower bound? Each of the methods that they used—narrative testimonies by witnesses and survivors, a graveyard census, and a retrospective mortality survey—are, in and of themselves, likely to underestimate the actual number who died during the occupation. Relying on narrative testimonies is problematic because in many cases massacres and deaths go unwitnessed or survivors refuse to testify about what happened.[3] Graveyard censuses omit deaths when victims are buried *en masse*, buried without a marker, or not buried at all—which is often the case during violent crises and famines. Retrospective mortality surveys underestimate mortality when deaths are "clustered" in families and there are no survivors in the country to report what happened.[4] If estimates from these three methods were simply added up, there would of course be risk of overestimation—multiple counting of the same deaths among different sources. However, Silva and Ball took painstaking efforts to avoid double-counting across different methods of estimation by detecting and eliminating duplicates. Hence their final casualty count is extremely well-documented and robust to evidentiary challenges, yet also likely to be lower than the "true" total. Indirect estimation thus provides a useful complement to their estimation of excess mortality.

East Timor, a very small country, is also an important case study of excess mortality. If the most commonly cited figure of 200,000 casualties during the first five years of Indonesian occupation is reasonable, then the Indonesian invasion of East Timor could have produced one of the highest *proportionate* death tolls of any war or mass murder in recent history. According to Kiernan (2003), the proportion of initial population who died in East Timor from 1975-1980 is on par with, if not slightly above, the proportion of the original population killed during the Khmer Rouge regime in Cambodia (21 to 26 percent).[5] Chomsky (1999) has claimed that a death toll of 200,000 would make it the highest proportionate death toll of any war since the Holocaust. Yet some experts estimate the casualty count to be as "low" as 60,000, or less than 10 percent of the original population (Hull 2004), thus it is important to consider the issue carefully.

The availability of Portuguese censuses prior to the Indonesian takeover gives us a unique estimate of the pre-invasion population, something largely unavailable in other historical cases of colonization. Timor's isolation as an island means that out-migration was necessarily quite limited. By and large refugees displaced by the Indonesian invasion fled into East Timor's vast forests and mountains.[6] Crossing the border into West Timor or fleeing by boat to a nearby

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[3] The opposite bias is also possible: that many survivors will report the same incident and thus lead to an overcount of the number who died, but Silva and Ball take painstaking efforts to eliminate such duplicate reporting. They also estimated that after accounting for recall bias, the number who died in East Timor of conflict-related deaths could be as high as 180,000.

[4] Here again, the opposite is possible: multiple surviving family members could report the same death. However Silva and Ball have taken measures to guard against such overcounting.

[5] Note that this percentage is slightly misleading as deaths do not occur only among those who were alive in 1975, but also among those born afterward. However this figure provides a rough estimate by which to compare the casualty count.

[6] Less than 5 percent of East Timor's land area is arable (CIA 2005).

island generally meant arriving in Indonesian territory, not an enticing prospect. Australia was close enough to receive some refugees, but these arrivals are well-documented. Hence, East Timor offers a unique perspective on the demographic impact of political annexation.[7]

Quantitative representations of human rights violations, such as death counts, are inherently controversial, because perpetrators often desire to discount the importance of the event while advocates may be tempted to overestimate what happened in order to draw public attention. Scientific evaluations of the evidence thus provide an appealing alternative to political debate. This paper is one of only a handful of serious efforts to estimate excess mortality in East Timor during the period of Indonesian occupation. Most efforts have focused only on the first five years of occupation, when it is believed population losses were the most dramatic (cf. Kiernan 2003; Cribb 2001). The general literature on East Timor cites a near-ubiquitous figure of 200,000 casualties (cf. Amnesty International 1997; Pilger 1994a; U.S. Congress 2000; Huridocs 2005), though the derivation of this number has not been well-documented.

The remainder of the paper proceeds as follows. First, the salient features of East Timor's history are laid out to provide some background to the study. Second, crude estimates of excess mortality based on population growth rates are given. The third section estimates excess mortality using age-specific death rates and all available information about migration. There my results are presented and documented. The fourth section concludes with a discussion of sensitivity testing of the results and compares my findings to other estimates.

Background

East Timor lies on an island just north of Australia on the eastern edge of the Indonesian archipelago (Figure 1). Its population is a mixture of Melanesians, Malays, and Chinese. The Portuguese colonized East Timor in 1520. Over the following centuries, Spain, the Netherlands, Britain, and Japan attempted to wrest control of the country from Portugal, but only Japan was successful in occupying East Timor briefly during World War II. Portugal regained control of East Timor following World War II. After a 1974 coup in Lisbon, the newly-established Portuguese Junta de Salvação Nacional declared that Portugal would withdraw from its overseas territories. East Timorese independence appeared to be inevitable (Lawless 1976).

Even before the Indonesians invaded, the inevitability of independence was a contentious and ultimately violent issue inside East Timor (Huridocs 2005; Nichertlein 1977). Fretilin (Frente Revolucionaria Timor Lest Independente), a popular left-wing movement, wanted to declare full independence. A second group, UDT (Uniao Democratica Timorense) wanted to remain linked with Portugal. The least popular group, Apodeti (Associao Popular Democratica Timorense), wanted autonomous integration into Indonesia, though Indonesia made it clear that autonomous integration would not be possible (Lawless 1976; Houk 1978). Initially UDT and Fretilin were in alliance, but UDT later withdrew and the two groups clashed violently. On

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[7] Several authors have suggested that what happened in East Timor was a genocide (East Timorese being a national group whom the Indonesians attempted to exterminate), while others strongly contest this definition, particularly because it has been difficult to establish clear evidence of "genocidal intent." This paper is not the correct forum for such a debate, and hence I simply refer to what happened in East Timor as "annexation" or "occupation." From a demographic standpoint, the importance of the occupation is that it involved a massive number of excess deaths, regardless of whether it meets the legal standards for "genocide" or not.

November 28, 1975, Fretilin unilaterally declared East Timorese independence. Nine days later Indonesian forces invaded.

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Figure 1. Map of East Timor in the Southeast Pacific Ocean.

On December 7, 1975, approximately 2,000 Indonesian paratroopers and marines and 20 warships began attacking Dili (the capital) and other coastal areas, causing at least 500 Timorese casualties (Lawless 1976). Fretilin is said to have put up a surprising amount of resistance given its technological inferiority, but Indonesians still conquered key strategic areas. The UN Security Council called on Indonesia to withdraw from East Timor two weeks later, but to no avail. Indonesia only stepped up its continued incursions into rebel-held areas under the veil of anti-communism. A second invasion took place on December 25, 1975.

In 1976, Indonesia officially incorporated East Timor as its 27th province (CIA 2005). The United Nations vocally condemned the annexation of East Timor, but other superpowers—particularly the United States and Australia—were silent on the issue. The United States never formally recognized Indonesia's annexation of East Timor, but also never publicly objected to it. Indonesia portrayed East Timor as an emerging communist nation, virtually guaranteeing U.S. support (Nichertlein 1977; Crossette 1994). The Indonesian invasion into East Timor began a mere 12 hours after U.S. President Ford left Jakarta, which is widely seen as evidence of American acceptance of Indonesia's conquest of East Timor (Zunes 2000; Monk 2001; Kohen and Taylor 1979). The United States supplied the arms used by the Indonesian military and continued its military support long after the annexation of East Timor (Sidell 1981).

For Australia, Indonesia was a crucial trading partner and consideration to diplomatic relations was given more weight than ethical concerns (Wheeler and Dunne 2001). In 1977, Australia formally recognized Indonesia's annexation of East Timor on the grounds of

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[8] Downloaded from http://www.ausaid.gov.au/hottopics/etslideshow/etintro.html on February 10, 2006. See http://www.ausaid.gov.au/legal/default.cfm for full copyright notice.

"realpolitik." However, in the last decade of Timorese occupation there was significant pressure within Australia by human rights organizations to raise the Timor issue (Kiernan 2002).

Indonesia publicly claimed that what happened in East Timor was not a military takeover; rather volunteers from its military went to assist a pro-Indonesian Timorese political group in a war with a Marxist-controlled group, Fretilin (Sharkey 1977). It also maintained that the Timorese had willingly accepted Indonesian involvement. For example, a letter to the editor in the *New York Times* written by the U.S. counselor at the Indonesian embassy stated:

> Indonesia will not take over Portuguese Timor but will accept integration, should the people of the area democratically, and without terrorists' guns pointed at their heads, choose this course. (Abdullah 1976)

Yet the evidence that Indonesian rule in East Timor was anything but voluntary is overwhelming. In the *Sydney Morning Herald* on April 5, 1977, the Indonesian foreign minister was quoted as saying: "Fifty thousand people or perhaps eighty thousand might have been killed during the war in East Timor... It was war... Then what is the big fuss?" (as cited in Kohen and Taylor 1979). Two joint Congressional hearings documented testimony from dozens of experts on East Timor on the impact of Indonesian violence toward Timor (U.S. Congress 1999a, 1999b). Eyewitnesses and experts described extensive bombing in the mountains where many Timorese had gone to seek refuge following the 1975 attack. They also told of the killing of entire villages near where Fretilin guerillas were operating, and the killing of anyone suspected to have any association with Fretilin (Sharkey 1977). Survivors have corroborated in great detail the brutality of Indonesian occupation (Jardine 1995; Pilger 1994a, 1994b).

Journalists and aid workers had only limited access to East Timor until 1989; hence knowledge of the extent of atrocities committed during the Indonesian annexation of East Timor is limited. Indirect estimation of excess mortality may be the best way to determine what happened in East Timor during Indonesian occupation. This paper first presents a crude growth-rate estimate of excess mortality to obtain a broad picture of what happened, and then presents more specific estimates by age and sex to determine excess mortality in East Timor during the Indonesian occupation.

Simplistic Estimates of Excess Mortality

In order to get a sense of excess mortality, it is useful to begin with a simplified model. We choose December 31, 1999, as a useful stopping point, as the violence after the August elections lasted for a few months. We can express the actual[9] population of East Timor on December 31, 1999, as:

$$P_{\text{Act1999}} = P_{\text{Act1975}} + B_{\text{interim}} - D_{\text{interim}} \pm M_{\text{interim}}$$

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[9] For ease of notation, I am equating actual population with the officially recorded population, even though they are not necessarily the same thing. Problems with census data are discussed in the next section.

where:

$P_{Act1999}$ is East Timor's population on December 31, 1999

$P_{Act1975}$ is East Timor's population on December 6, 1975

$B_{interim}$ is the number of live births during the period

$D_{interim}$ is the total number of deaths that occurred during the period

$M_{interim}$ is the <u>net</u> number of international migrants from 1975 to 1999

We can define two types of death during the period: *expected* and *excess*, where:

$D_{expected}$ is the number of deaths that would have been expected during the period if mortality rates held constant[10]

D_{excess} is the number of deaths that are not explained by the mortality rates in the starting year, a portion of which are presumably related to the Indonesian occupation

It follows that:

$$D_{interim} = D_{expected} + D_{excess}$$

Similarly, births and mortality totals are comprised of expected values and unexpected values. In the case of migration we take into account reported totals during the period in order to reduce the value of unexpected migration:

$$B_{interim} = B_{expected} \pm B_{unexpected}$$

$$M_{interim} = M_{expected} \pm M_{reported} \pm M_{unexpected}$$

Using a growth rate or another formula, we can derive an estimated 1999 population:

$$P_{Est1999} = P_{Act1975} + B_{expected} - D_{expected} \pm M_{expected} \pm M_{reported}$$

If we then subtract the actual 1999 population from both sides of the equation above, we find that all terms on the right hand side cancel except the number of deaths:

$$P_{Est1999} - P_{Act1999} = P_{Act1975} - P_{Act1975} + (B_{expected} - B_{interim}) - (D_{expected} + D_{expected})$$
$$+ (\pm M_{expected} \pm M_{reported} - \pm M_{interim})$$

$$P_{Est1999} - P_{Act1999} = D_{excess} + (B_{unexpected} \pm M_{unexpected})$$

As $(B_{unexpected} \pm M_{unexpected})$ approach 0:

$$P_{Est1999} - P_{Act1999} \approx D_{excess}$$

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[10] In fact, this is a conservative estimate, as most developing countries have experienced a "mortality transition" in the past half century, whereby mortality rates have been steadily decreasing.

In other words, since what we are really interested in is excess deaths, we will try our best to reduce the absolute value of unexpected births and unexpected migrants, so that the estimated minus actual population will primarily be comprised of excess deaths. If fertility or net migration were lower than expected, this would inflate our count of the excess deaths. Conversely, if fertility or net migration were higher than expected, or if "normal" mortality rates fell[11] over time, we would underestimate excess mortality.

We also face an additional problem: there are no official records for Timorese population on December 6, 1975, nor are there any for the population on December 31, 1999. Table 1 lists the population data sources that will be used in this paper. As it indicates, the last recorded population census prior to 1975 was Portugal's 1970 census of its overseas territories. However, Portugal updated its census count with records of births, deaths, and net migration in 1971 and 1972.[12] Most population data during the period of occupation comes from Indonesian sources. Some post-independence data are available, but detailed population counts by age and sex from the 2004 census have not yet been released.

Hence our "actual" population counts in 1975 and in 1999 will actually be estimates based on census data before and after the occupation, which adds another layer of potential error. Moreover, official counts done prior to the invasion are thought to be flawed. The Portuguese collected a poll tax on the East Timorese, so it is likely that their population numbers are an undercount (Cribb 2001). Yet Indonesian census-takers were unlikely to be warmly received by East Timorese during the occupation, so in a sense the rates of enumeration before and during the occupation may be fairly comparable.

When all the potential sources of error are considered, the cost of producing an estimated count of excess mortality may, to some, appear to outweigh the benefit of having a potentially flawed estimate. This opinion is perhaps understandable. We will never know the real number of East Timorese killed directly or indirectly by Indonesians, and it would be dishonest to claim otherwise. Yet if we are careful and responsible with our methods and consider the possible sources of error, we can produce a reasonable estimate of this figure. If our methods here are carefully documented, scholars and critics can replicate the results, judge the integrity of the estimate, and improve the estimate if new historical information later appears.

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[11] It is nearly impossible to imagine that natural mortality rates would have risen during the period, as this would be contrary to the experience of peaceful and unoccupied developing countries during this period.

[12] Portugal also published a 1973 update, but it did not contain births and deaths for East Timor.

Table 1. Sources of population data for East Timor, 1960–2004.

Applicable Year	Series Title	Institutional Author	Contains
1960	*Anuario Estatístico Provincias Ultramarinas*	Portugal Instituto Nacional de Estatística	Official census; possible undercount due to poll tax
1970			
1971			Contains information on births and migration only
1972			
1970 – 1999	*World Population Prospects*	United Nations	Historical estimates of population totals, fertility, migration, crude death rates
1972	*Revista Do Centro de Estudos Demograficos*	Portugal Instituto Nacional de Estatística	Estimated fertility and mortality rates from 1972
1980	*Sensus Penduduk: Rumahtangga Dan Penduduk, Timor Timur*	Bagian Statistik Demografi	Official census; possible undercount (internally displaced persons in remote areas); but a political incentive to overcount
1990			
1991	*Indonesia Demographic and Health Survey*	Central Bureau of Statistics Indonesia et al.	Contains 3-year retrospective age-specific fertility rates and 10-year retrospective infant and child mortality rates for East Timor
1994			
1997			
2000	*International Data Base*	U.S. Census Bureau	Population counts
2001	*Suco Survey*	Asian Development Bank	Population total
2004	*2004 census*	Direcção Nacional de Estatística de Timor-Leste	Population total; age and sex counts not yet released

A simple way to estimate excess deaths is to apply East Timor's average annual growth rate from 1960 to 1972[13] to the period from 1972 to 2000. The "actual" 2000 total can be subtracted from this estimated total to obtain an estimate. The growth rate formula estimates East Timor's expected 1999 population at 1,065,531. We do not have a recorded total for 1999, but we know that the 2001 Suco survey counted 787,338 persons in East Timor (Asian Development Bank 2002). Projecting the average annual growth rate from 1972 to 2001 (0.72 percent)[14] back

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[13] The average annual growth rate increased from the 1960-1970 period to the 1970-72 period. To err on the conservative side, I obtain an average annual growth rate from 1960-1972.

[14] The estimated growth rate is extraordinarily small because of the massive mortality and out-migration during the period; but using a smaller growth rate in a backward projection errs on the side of caution because it produces a larger estimate of the actual 2000 population.

to 1999 implies a population of 781,684 in December of 1999. If we instead take the growth rate from the 2001 Suco survey to the 2004 census (5.36 percent) and project backward, this would imply a 1999 population of 746,263. These figures imply an excess mortality of approximately 284,000 to 320,000 during the period. An illustration of the growth rate method is given in Figure 2. As the figure illustrates, the dip in population from 1970 to the 1980 period and onward is quite dramatic.

A growth-rate calculation done for the entire period is obviously problematic, however. During the past half-century, hardly any human population has experienced a period of 24 years with an unchanging annual rate of growth. Constant population growth requires a stable age structure, constant levels of in- and out-migration during the period, and constant age-specific fertility and mortality rates. East Timor fits none of these assumptions.
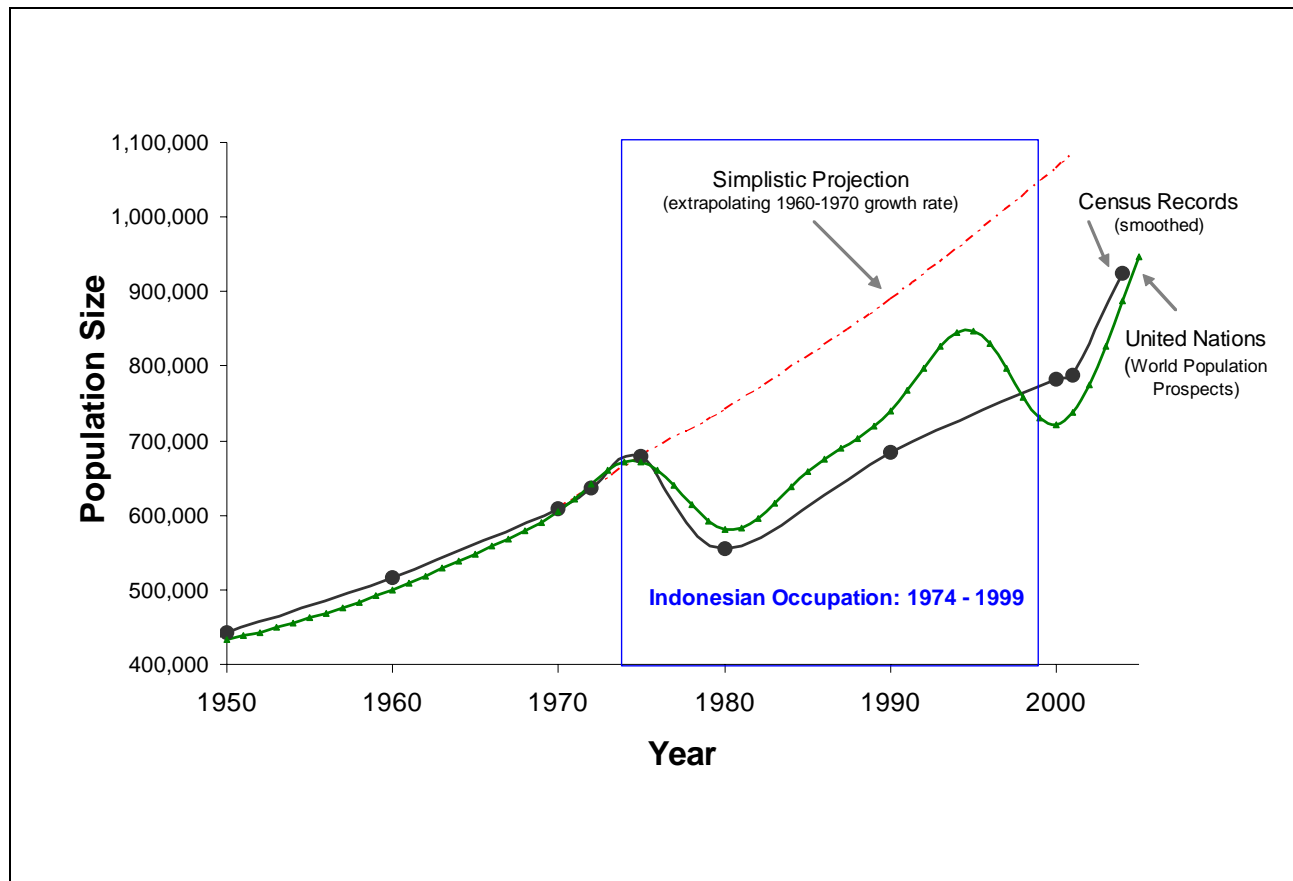

Figure 2. Recorded population compared with simplistic population projection: East Timor, 1950–2005. Sources: Census data from Portugal Instituto Nacional de Estatística (1970, 1972); Bagian Statistik Demografi (1980, 1990); Asian Development Bank (2002); Direcção Nacional de Estatística de Timor-Leste (2005); United Nations (2005) and author's calculations.

Age-Specific Estimates of Excess Mortality

Initial crude estimates based on growth rates from 1975 to 1999 suggested a maximum of 284,000 to 320,000 missing persons during the period. These crude estimates based on growth rates provide a useful hypothetical maximum estimate of excess mortality in East Timor during the Indonesian occupation. But they do not account for the changing age structure of the population nor do they allow us to examine the age and sex composition of the "missing" population.

Fortunately we can achieve even more specific estimates of excess mortality by producing projections of population by age and sex. These age- and sex-specific projections have two major advantages over the simplistic total population estimates produced above. First, they take into account the ways in which changing age structure produces different composite fertility and mortality levels over the period, even when age-specific rates remain the same. Second, age- and sex-specific projections help us to distinguish between two types of excess mortality: deaths to the initial population alive on December 6, 1975 (who would be 25 years old or more if they survived to December 31, 1999) and deaths or non-births to children who would have been expected during the period. The former estimates are generally more reliable than the latter, because we know that "missing" persons age 25 and above in 1999 either died, migrated outward, or were not enumerated in the second census. With the population of incoming births (those age 25 and below in 2000), however, it is impossible to distinguish between child deaths and children not born (due to reduced fertility rates) from census data alone.[15]

For these reasons, demographers prefer to use a Leslie Matrix to project populations. A Leslie Matrix employs age-specific mortality and fertility rates to provide a transition matrix that is more precise than a simple projection based on population growth rates (Wachter 2002). The R Programming language (R Development Core Team 2006) was used for all calculations. Appendix A provides detail about the computation and usage of Leslie Matrices. Estimates of the current population (expressed as vectors) can be multiplied by the matrix to produce new population vectors.

To make use of all existing information, we break the calculation of excess deaths down into several time periods (as determined by the available data). Each time period can provide us with an estimate of excess deaths that we can sum to approximate the total excess deaths during the entire 1975–1999 period. First we establish the size of the baseline starting population. Then, using narrative historical information and Leslie matrices, we estimate excess mortality from December 7, 1975 to 1980; from 1981 to 1990; and from 1991 to December 31, 1999.

How Big Was the Population of East Timor on December 6, 1975?

The population of East Timor on December 6, 1975, is one of the most important calculations in this estimation process. Error in the initial estimation will be further exacerbated over time by the application of population growth rates. Even though projecting the December 1970 population

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[15] The same would usually be true for immigrants as well: it would be difficult to distinguish whether they never arrived or whether they arrived and died before the census, except that in East Timor, the later surveys distinguish between household heads born in East Timor and those born elsewhere. This paper limits its mortality estimates to the native Timorese population wherever possible, so in-migrants are not a major concern.

forward by five years seems relatively straightforward, there are questions about the reliability of the 1970 number. The Portuguese collected a poll tax during each census and hence all of their population counts were likely to have been understatements (Cribb 2001). What Cribb does not mention, however, is that undercounting the 1975 population will make excess mortality counts more *conservative* if later censuses are better enumerated. Hence we rely on the Portuguese numbers.[16]

Projecting forward from the June 1972 estimate to December 1975 with a Leslie matrix is problematic because Leslie matrices deal with whole years. Growth rates can easily be multiplied by fractions of a year, but it is not possible to multiply by fractions of a Leslie matrix. Therefore we produce a five-year Leslie Matrix from which to project the December 1970 population forward to December 1975.

The Portugal Instituto Nacional de Estatística (1985) provides age-specific mortality rates from 1972. Age-specific mortality rates are displayed as survival probabilities in Figure 3. Comparable survival probabilities for 1975, 1980 and 1990 were calculated from Coale-Demeny Model West Life Tables using Indonesian age-specific death rates. Why Indonesia? Here we want to understand the counterfactual: what East Timorese mortality might have looked like in the absence of the Indonesian invasion. East Timor's age-specific death rates would be problematic here because they already account for increases in deaths due to conflict, famine, and forced migration. Indonesian crude death rates are a convenient point of comparison to compute Coale-Demeny Model West age-specific mortality rates. Figure 3 shows that the pattern of death at younger ages is a different shape for the 1972 baseline Portuguese calculations as compared to the Coale-Demeny estimations. Thus half of all subsequent projection scenarios, even for later years, use the 1972 mortality rates while the other half use the Coale-Demeny period-specific mortality rates.

The Portugal Instituto Nacional de Estatística (1985) estimates that in 1972 East Timor's total fertility rate (TFR) was 5.1 births per woman over her lifetime. Unfortunately it does not provide any information on what the age-specific rates are. We relied on age-specific fertility rates from the East Timor sample of the 1991 Demographic and Health Survey (DHS) (Central Bureau of Statistics Indonesia et al. 1992) to obtain a proportionate distribution of age-specific fertility rates in 1972. We obviously cannot be certain that the distribution was the same in 1972, but the total fertility rates were quite close (5.1 in 1972 and 5.6 in the 1991 DHS), which suggests that there probably was *not* a dramatic shift in the age pattern of fertility from 1972 to 1991. Interestingly, these figures suggest that there was actually an *increase* in fertility during the period. It is not known whether this represents an actual increase or whether sampling, enumeration, and other methodological problems with the Portuguese statistics can explain the discrepancy. (The higher fertility rates are likely to be correct, as they were corroborated by even higher fertility rates for 2000-2005 from the United Nations). Nonetheless, the higher fertility rate from the 1991 DHS indicates that the 1972 fertility rate of 5.1 is likely a conservative estimate. Figure 4 shows age-specific fertility rates ($_nF_x$) for East Timor in 1972, as well as comparable DHS estimates from 1991, 1994 and 1997 and the United Nations estimate for 2000-2005.

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[16] There was a survey done by the Catholic Church in 1974 (Teixeira 1974) and one done in 1978 by the Indonesian army, but these population counts are also thought to be flawed (Hull 2003).
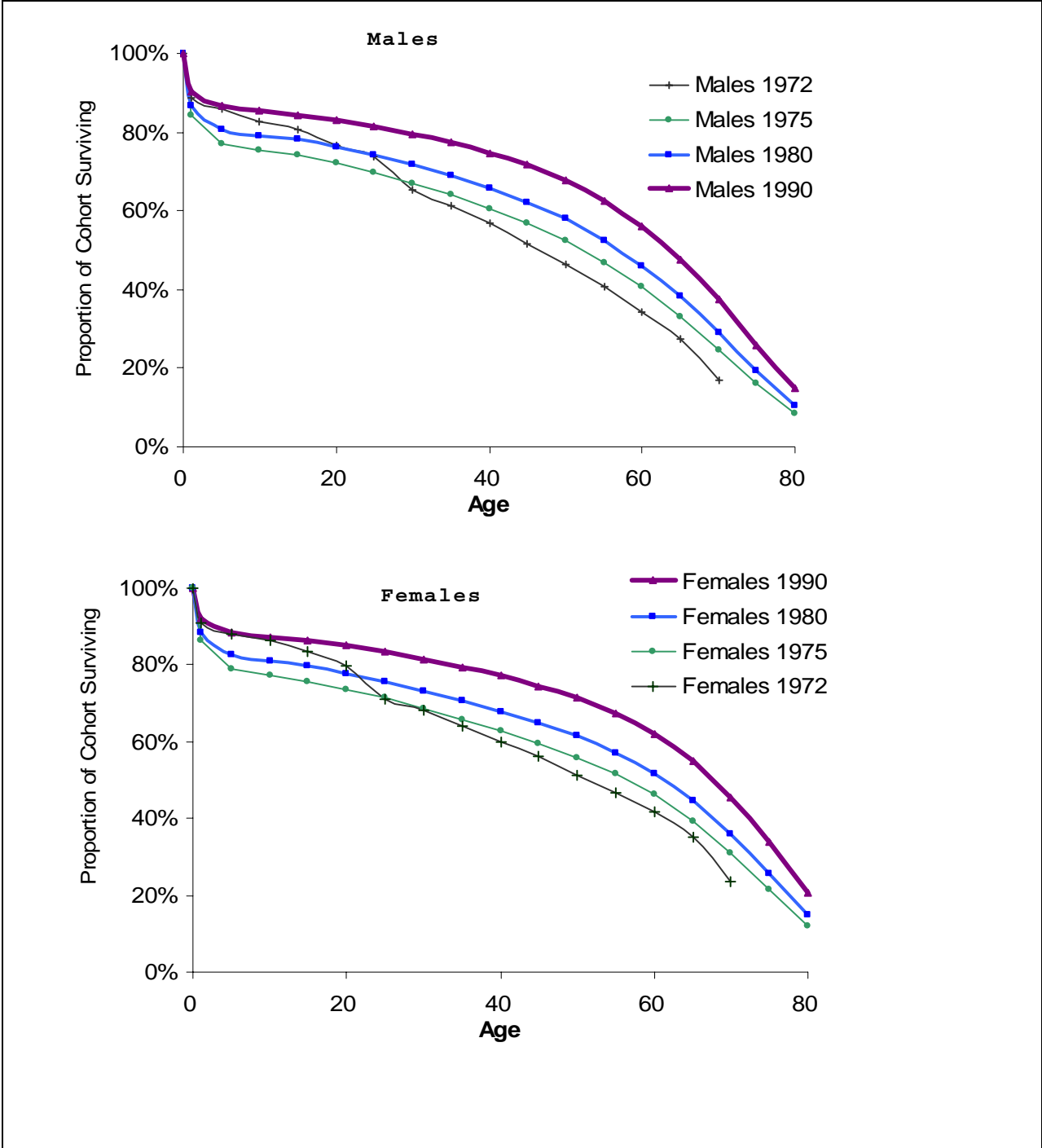
Figure 3. Cohort survivorship probabilities used for projections, 1972-1990. Sources: Portugal Instituto Nacional de Estatística (1985) and author's calculations using Coale-Demeny Model West Life Tables for Indonesia.
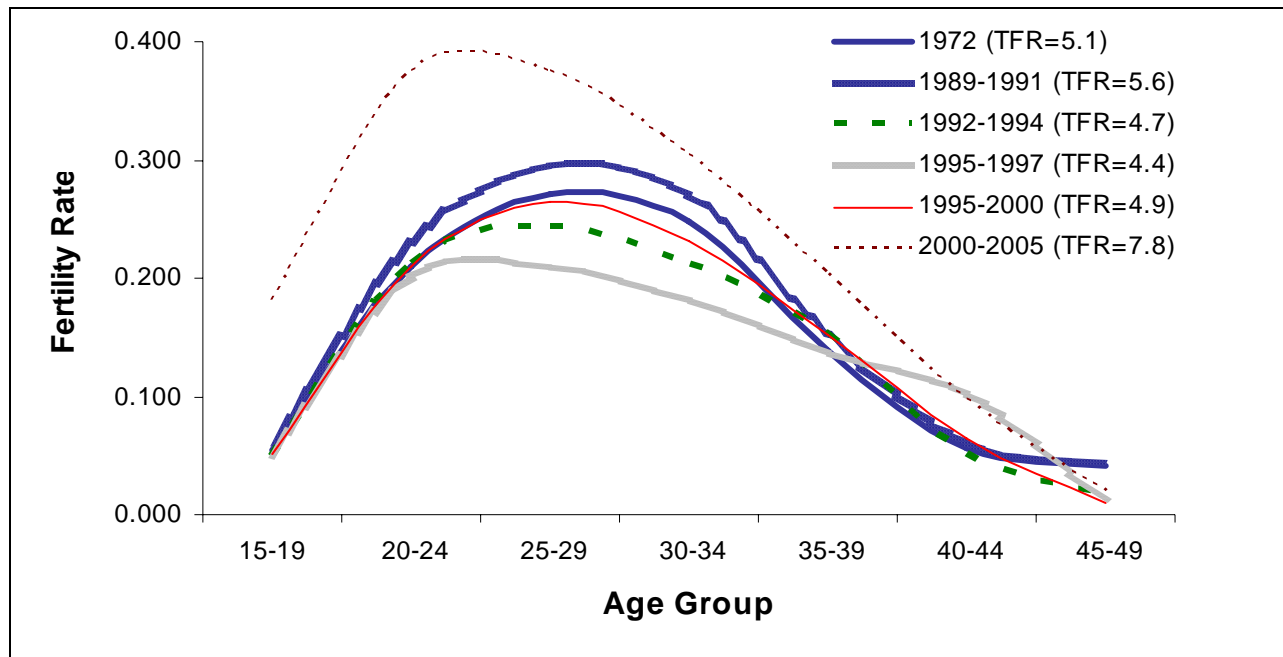
Figure 4. Age-specific fertility rates, East Timor, 1972 – 2005. Sources: Central Bureau of Statistics Indonesia et al. (1992, 1995, 1998); Portugal Instituto Nacional de Estatística (1985); United Nations (2005). Note: 1972 fertility rates were assumed to follow the same age-specific pattern as fertility rates from 1989-1991.

In order to compute the starting (1975) population, age-specific fertility rates were combined with age-specific mortality rates to produce Leslie Matrices for population projection (see Appendix A for a description of Leslie Matrices). For the period from 1970 to 1975 we had to take into account the thousands of refugees who fled from East to West Timor in early 1975 due to fighting between Fretilin and UDT. It is estimated that as many as 3,000 persons (largely former UDT combatants and their families) fled to Indonesian Timor before the Indonesian invasion, and that an additional 2,500 emigrated to Australia (Lawless 1976). The literature suggests that at least 1,500 (Kiernan 2003) and at most 13,000 (Hull 2003) were killed during the conflicts between Fretilin and UDT. I approximate that from these sources the population lost an estimated 10,000 persons prior to the 1975 invasion. Thus my revised estimate of the 1975 population is 648,730. This estimate is near to Kiernan's (2003) suggested range of 652,250 to 707,500 persons alive immediately prior to the Indonesian invasion. We do not have any information on the age or sex of pre-invasion refugees, so we reduce our counts of all population age and sex groups proportionately. The resulting population pyramid for 1975 is shown in Figure 5, along with the smoothed version done by the United Nations (2005). Both baseline populations are used in projection scenarios for 1980.
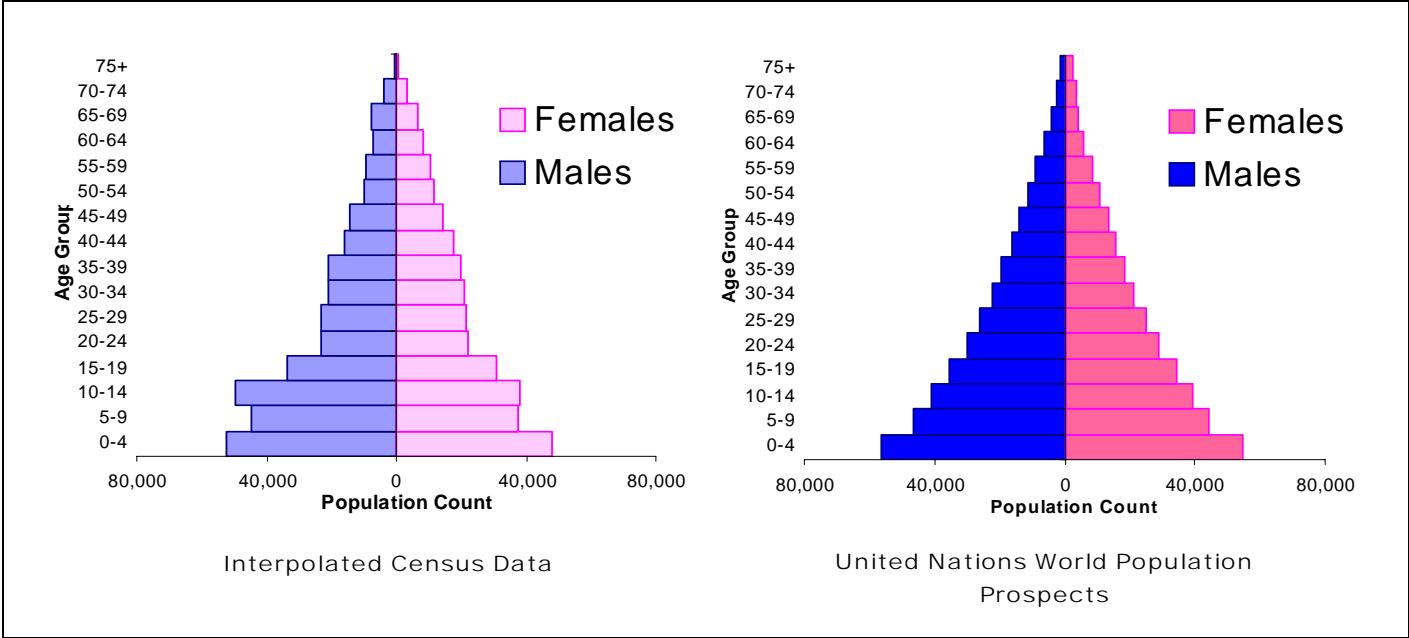
Figure 5. Age pyramid of East Timor, December 1975. Source: United Nations (2005) and author's calculations.

The 1975–1980 Period

In 1980, the Indonesians conducted a census of East Timor and counted 554,721 persons. Using different combinations of age-specific fertility and mortality rates for the 1975-1980 period, we calculate 18 different projection scenarios.[17] We compute the expected 1980 population as the <u>median</u> estimate of the resulting 18 different projections. This helps reduce the sensitivity of our estimate to any particular combination of fertility and mortality rates. Figure 6 shows the United Nations estimate for 1980 compared to the median projected 1980 population. Given that the estimated population is much lower than the median projected population, it is clear that there was substantial out-migration, severe under-enumeration in 1980, or excess mortality during the time period. Standard errors from the sample of 18 different projection scenarios are also shown for purposes of comparing amongst different age groups. We have shied away from displaying standard deviations and confidence intervals throughout this report because our "population" of projection scenarios aims to be exhaustive (all possible combinations of baseline population, fertility, and mortality) rather than selective (favoring estimates that seem "most reasonable").

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[17] In some scenarios fertility rates were revised downward for the period by 25 percent, as initial estimates produced an implausibly high number of missing infants.
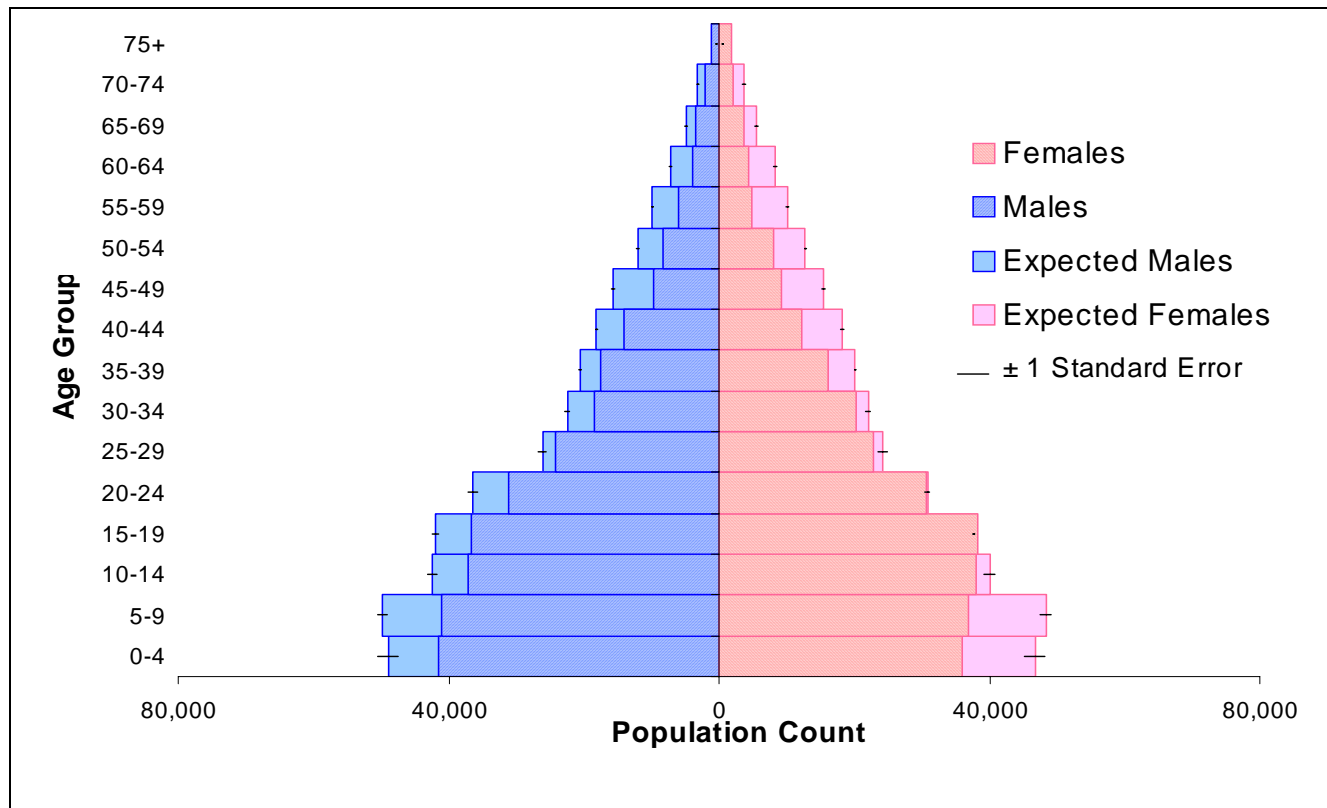
Figure 6. Expected versus reported population, East Timor, 1980. Source: United Nations (2005) and author's calculations. Note: Expected population refers to the median projection scenario and the standard error is computed from the set of alternative population projections.

Our estimate produces a total "missing" population of 125,700 (with an inter-quartile range[18] of 28,000) from 1975 to 1980. How reliable is this figure? Cribb (2001) claims at most 50,000 were killed by Indonesian forces and an additional 50,000 died of starvation or disease brought about by the occupation. Kiernan (2003) puts the death toll at 120,000 during this period. Others have claimed that 200,000 is more appropriate (Crossette 1994; Amnesty International 1997). Given the large rates of internal displacement, it is possible that thousands of survivors were not enumerated during the 1980 census and United Nations estimates. Additionally, given the antagonistic relationship between East Timorese and Indonesians, many may have hid during census counting. Under-enumeration would artificially inflate our estimate of excess mortality. Yet at the same time, Indonesia also had a major incentive to inflate its population count of East Timor in order to cover up the real number killed. Moreover, since the Portuguese estimates are also thought to be undercounts, the Indonesian undercount would have to be quite severe to inflate the count of excess mortality.

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[18] Absolute value of the difference between the 75th percentile and the 25th percentile.

It is estimated that 30,000 people left the territory between the 1975 invasion and 1979 (Anon. 1979). But by 1979, the majority of internally displaced people who had fled into the mountains and jungles reappeared. Additionally, there was a massive famine in the late 1970s (Sherlock 1996). Thus our estimate of 125,700 is on the high side but not out of the range of possibility.

Figure 7 shows the "missing" population by age and sex. Males have higher rates of excess mortality during the period, particularly those under the age of 25. Persons above age 45 also appear to have higher rates of excess mortality than middle-aged adults. Young children appear to be the most heavily affected group of all, accounting for nearly one-fourth of the estimated excess mortality from 1975 to 1980. Is this realistic? Infant mortality tends to be quite high during wartime (Urdinola 2004), so it is possible that this is a correct estimate of what actually happened. However as Cribb (2001) argues, the more likely scenario is that there was a drop in fertility from 1975 to 1980. It seems highly plausible that fertility would have declined during the 1975-1980 period, due to the high rates of internal displacement, the resulting breakup of families, food shortages, and lack of housing space. As noted previously, many of the projection scenarios reduced fertility by 25 percent to account for this decline.

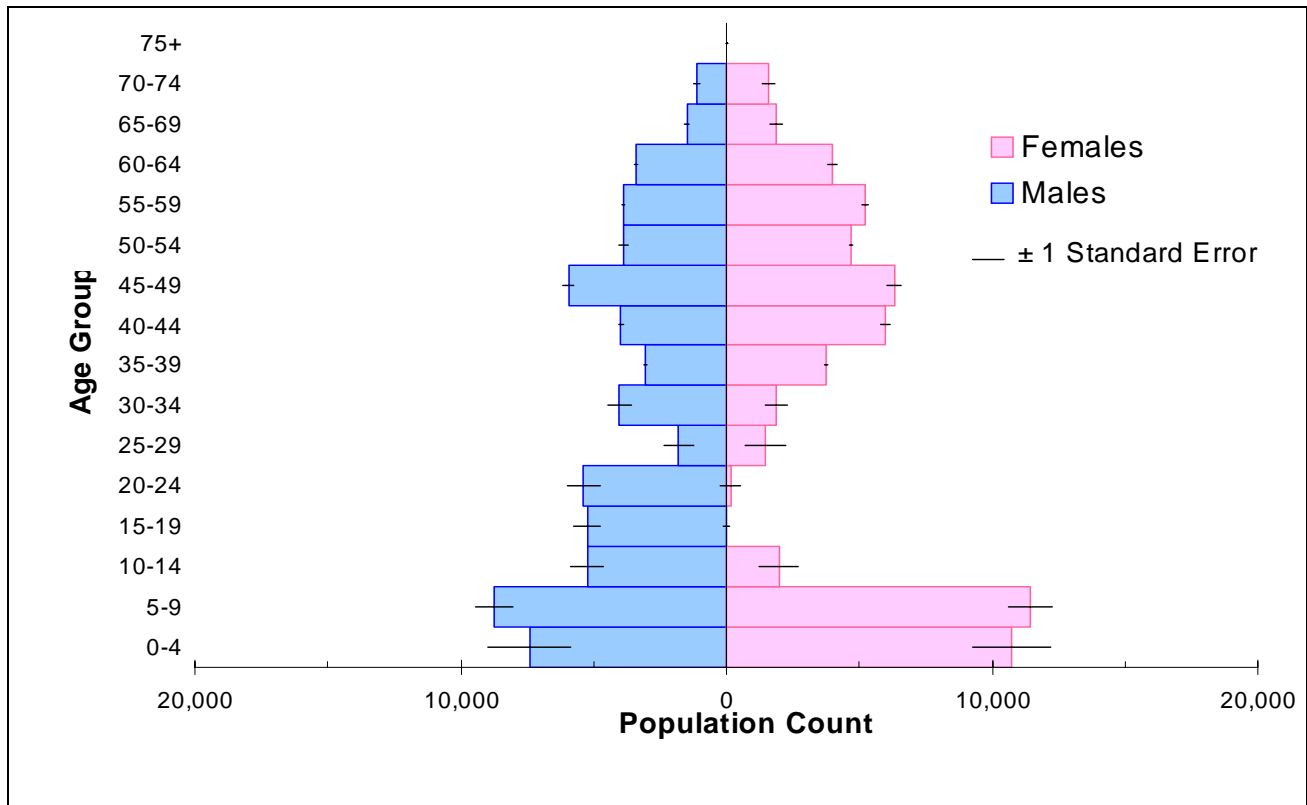Figure 7. Age structure of "missing" population, 1980, East Timor. Source: United Nations (2005) and author's calculations. Note: "Missing" refers to the difference between the median projection scenario and the recorded United Nations (2005) total.

Although it is possible that this excess mortality estimate is high due to an under-enumeration in the 1980 census, the age pattern is not suggestive of migration. The groups most impacted by mortality during the 1975–1980 period were the young and the old, the two groups least able to migrate on their own. These are also the two groups most vulnerable to disease and starvation. Hence one interpretation of Figure 7 is that the famine mortality from 1975 to 1980 was much higher than any combat-related mortality, an interpretation that is confirmed by much of the anecdotal literature.

The 1981–1990 Period

We can use similar techniques as above to estimate the excess mortality from 1981-1990. According to the Indonesian census, there were 747,557 persons in East Timor in 1990. However, due to the Indonesian trans-migration program, this total includes several thousand Indonesians. We need to exclude native Indonesians in order to avoid under-counting the number of "missing" persons. Other research has found that only 684,202 of these persons were living in households headed by a native of East Timor in 1990 (Hull 2003: 31).

We have very little information about the reliability of 1990 census data, and there are good reasons to believe that East Timorese may have avoided census enumerators, but also that Indonesians may have been tempted to overstate population totals in order to deflect attention to their annexation.

There was no new publicly available information on mortality rates from 1981 to 1990. Hence we use our results from the 1980 Coale-Demeny Model West Life Tables for Indonesia and the original 1972 mortality estimates from the Portugal Instituto Nacional de Estatística (1985). The former likely underestimate what Timorese mortality would have been in the absence of the Indonesian invasion, while the latter likely overestimate the same counterfactual. Fertility data was available from the 1991 DHS, but only for the three-year period prior to the survey. Hence we divided our estimation into two five-year periods: 1981 to 1985 and 1986 to 1990. For the 1986 to 1990 period we alternated between the DHS fertility and the United Nations fertility estimates, while for the 1981 to 1985 period we only used the United Nations 1980 fertility estimates. We computed a total of 16 different projection scenarios from 1980 to 1990. Figure 8 shows the median expected 1990 population versus the recorded 1990 population.

Figure 8. Expected versus reported population, East Timor, 1990. Source: United Nations (2005) and author's calculations. Note: Expected population refers to the median projection scenario and the standard error is computed from the set of alternative population projections.

The median projection scenario suggests that 86,200 persons were "missing" from 1981 to 1990. The age structure of these missing persons is shown in Figure 9. The missing population is concentrated among persons under 24 and among persons aged 40 to 59. Interestingly, women were affected more than men. There was a massive Indonesian trans-migration program that brought thousands to East Timor, but this should not have had any substantial effect on the results shown above unless there was substantial intermarriage among Indonesians and East Timorese because we considered only persons in households headed by a native East Timorese. None of the literature indicates that intermarriage was common.
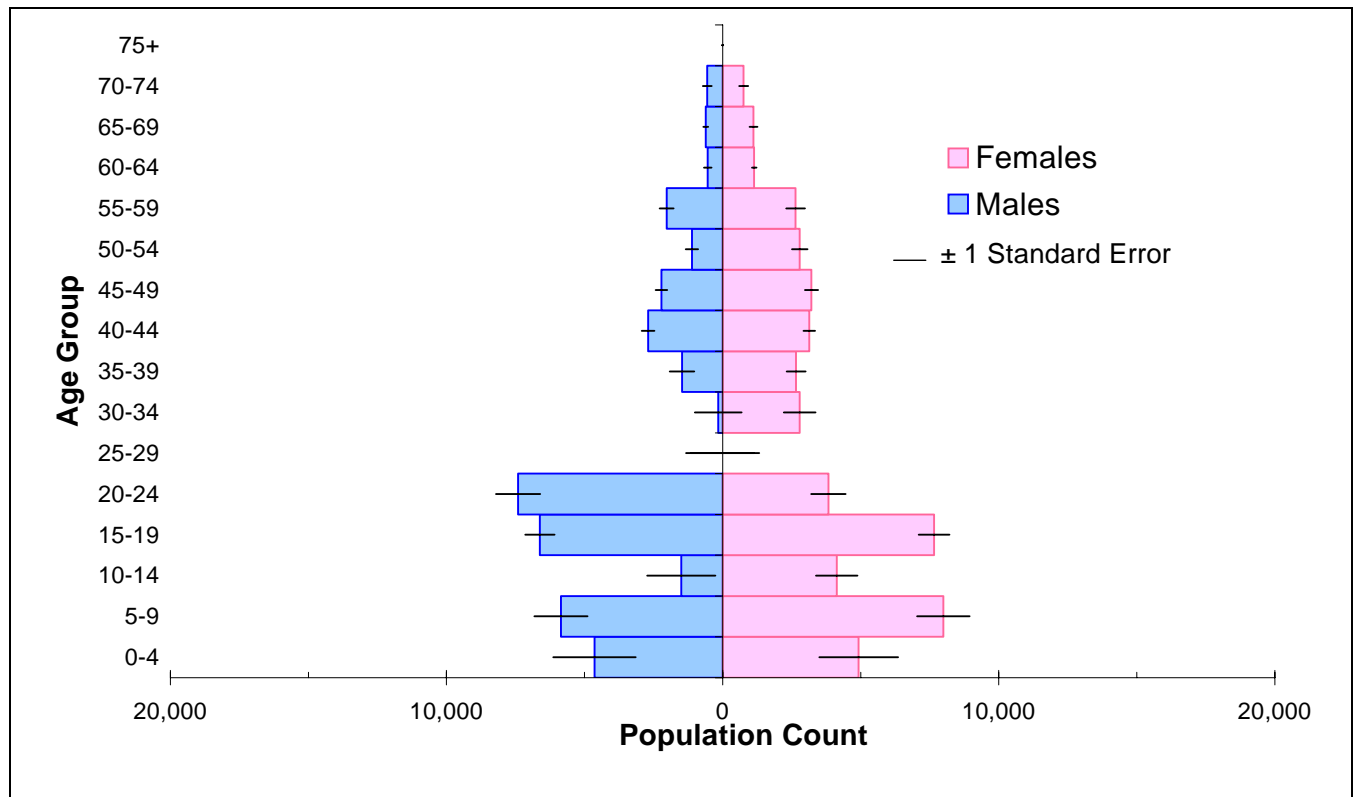
Figure 9. Age structure of "missing" population, East Timor, 1990. Source: United Nations (2005) and author's calculations. Note: "Missing" refers to the difference between the median projection scenario and the recorded United Nations (2005) total.

The 1991–2000 Period

Estimation of mortality during the 1991-2000[19] period is slightly more difficult due to the large-scale migrations which took place toward the end of the period. Following the August 1999 referendum and its subsequent violence, hundreds of thousands fled into West Timor (United Nations High Commissioner for Refugees 2000; Stahn 2001). Many returned in a short amount of time after the United Nations stabilized the situation. The United Nations estimates that eventually, 90 percent of the 250,000 East Timorese who sought refuge in West Timor during 1999 were successfully repatriated into East Timor (Dolan et al. 2004). By December 2000, at least 200,000 persons, or 80 percent of the refugees, had been successfully repatriated into East Timor. Therefore we need to incorporate what we know about excess emigration during the period in order to account for persons who were away in 2000 but would later return.

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[19] The post-election violence subsided by January of 2000 but data were all from July of 2000. Because of the low levels of violence during 2000 it is assumed that these five months did not make much difference in the overall totals.

Based on a combination of fertility and mortality rates during the period, as well as assumptions about out-migration, 16 different projections for the 2000 population were computed. Half of the projection scenarios reduced their final total by 100,000 to account for the refugees who left, while the other half reduced their final count by 225,000. The results are shown compared to the reported 2000 population from the United Nations in Figure 10.
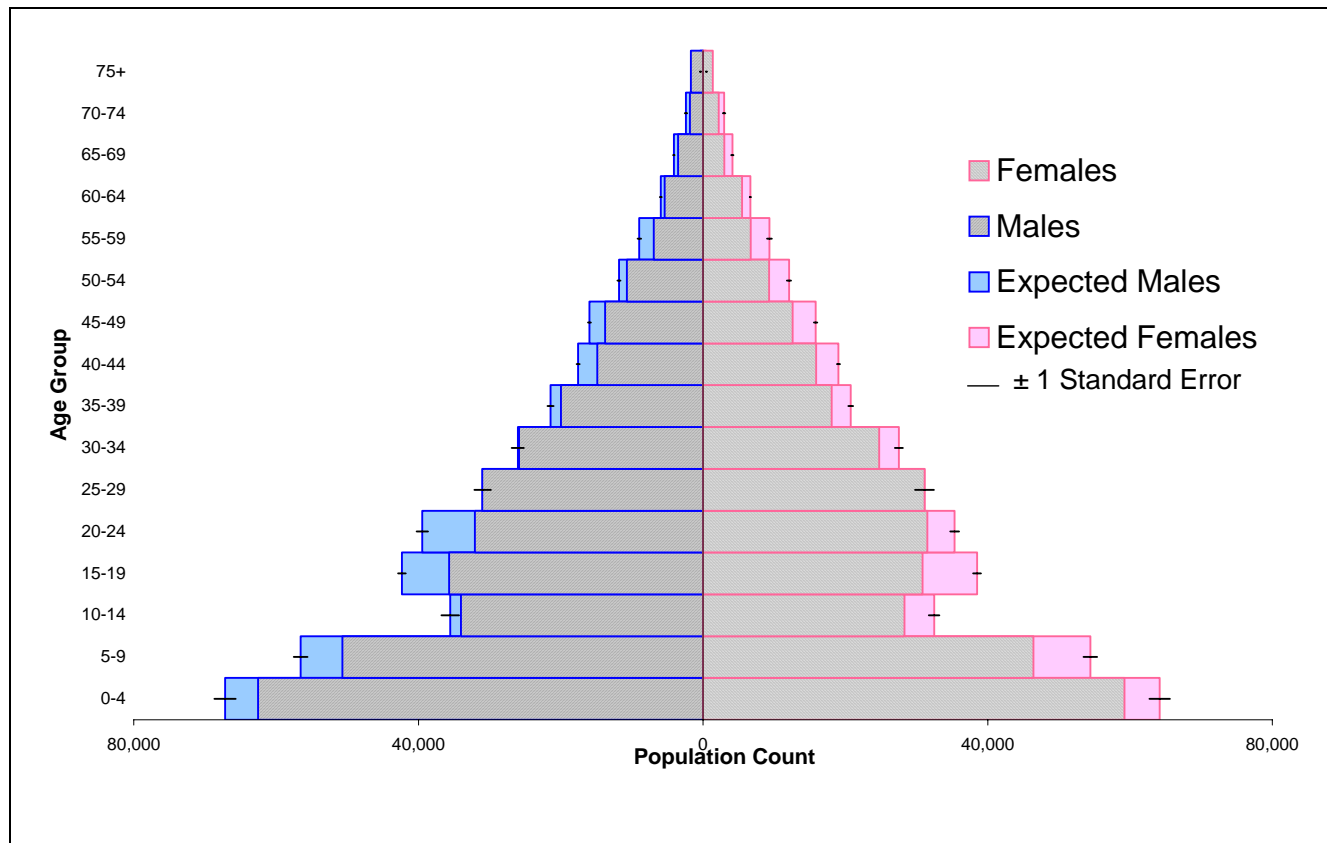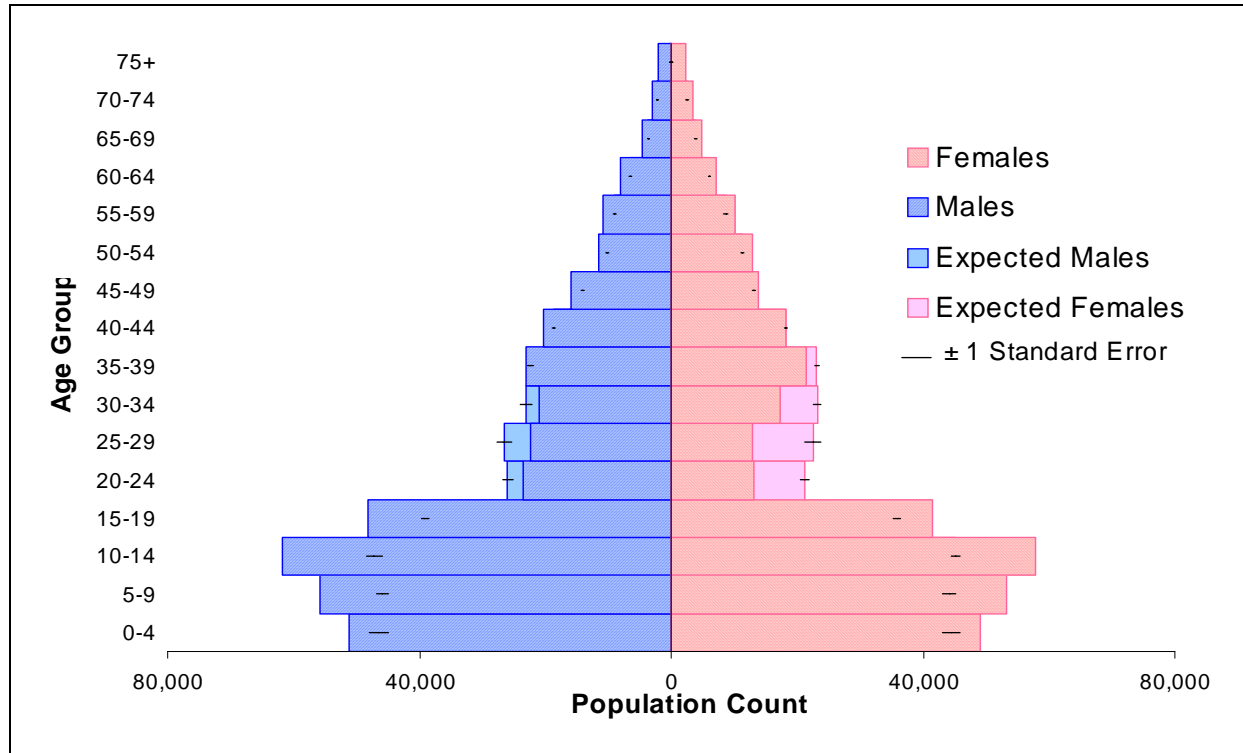

Figure 10. Expected versus recorded population, East Timor, 2000. Source: United Nations (2005) and author's calculations. Note: Expected population refers to the median projection scenario and the standard error is computed from the set of alternative population projections.

Without any knowledge of the age structure of refugees, I assumed they were evenly distributed across the existing age structure when I subtracted them from the estimated 2000 population. The resulting age structure of the median "missing" population in 2000, as shown in Figure 10, is heavily skewed toward persons aged 20-49 and toward younger children. It is also balanced in favor of women. This may indicate that young women of reproductive age were the most likely to migrate to West Timor during the post-election violence in 1999. Yet the age pattern of missing males is consistent with the targeting of working-age (and combat-age) young men by Indonesian forces and rebel groups. The total number of estimated "missing" persons from 1991 to 2000 (excluding returned refugees) is 34,000. Compared to totals from the previous decades, this is a rather "low" total.

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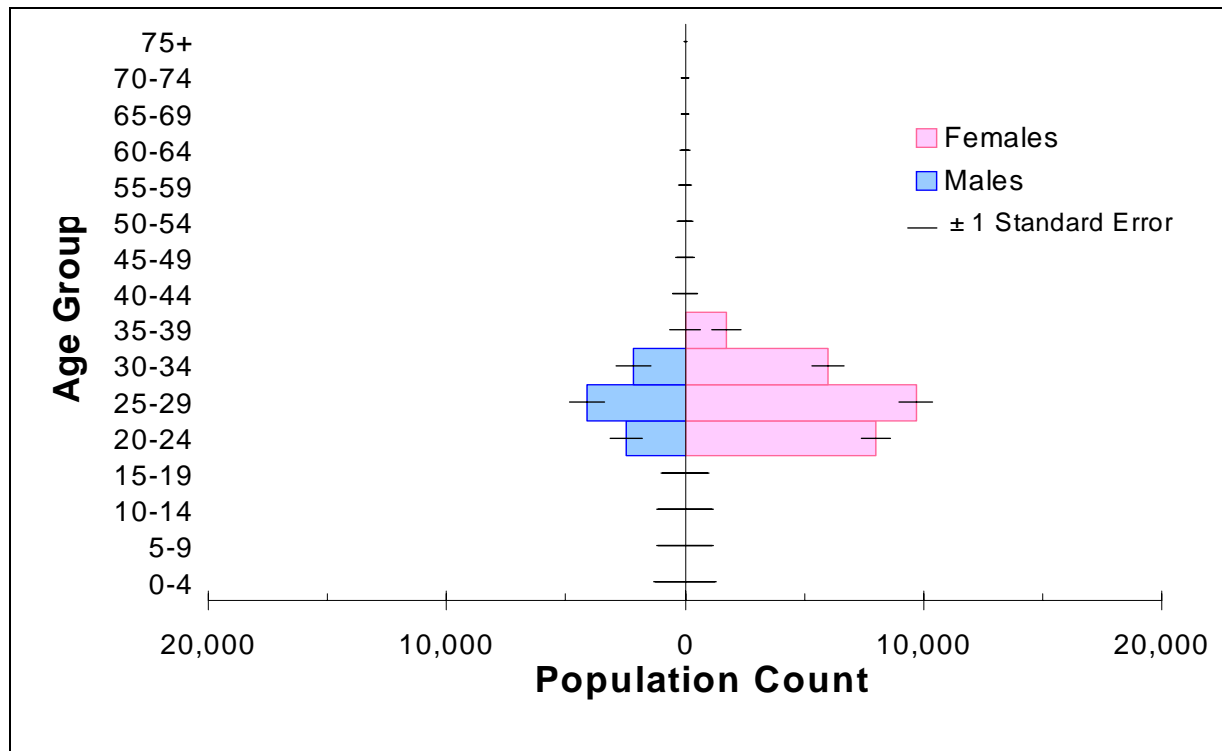
Figure 11. "Missing" population, excluding returned refugees, East Timor, 2000. Source: United Nations (2005) and author's calculations. Note: "Missing" refers to the difference between the median projection scenario and the recorded United Nations (2005) total.

Conclusions

There are two major ways to indirectly compute excess mortality in the absence of actual data on the number of casualties killed. The simplistic solution is to use a growth rate to estimate what the final population would have been, and then subtract the actual final population from that number. This is unsatisfactory, however. It does not account for the naturally-changing age structure of mortality and fertility during the period. Moreover, in a case like East Timor where a lot of persons died early on, a growth rate estimate would likely overstate excess mortality because it assumes these people would have gone on to bear children.

The second and more satisfactory way to indirectly calculate excess mortality, which this paper has employed, relies on age-specific fertility and mortality rates during intercensal periods to compare "actual" and "expected" population. However it is important to be clear that the result of such an exercise is not a total of excess mortality, but rather a total of "missing persons"—people who may have been missed in a later census, who may have moved out of the country, who might not have been born, or who might have prematurely died. From indirect data it is impossible to be conclusive about which of these sources caused the "missing" population, but experimenting with a variety of projection scenarios and examining qualitative evidence, as this paper has done, certainly helps.

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My intercensal results found that there were likely 125,700 "missing" persons in 1980, 86,200 in 1990, and 34,000 in 2000. These three totals sum to 245,900 missing persons from the period 1975 to 2000. However after accounting for "excess" (unanticipated) population by birth cohort recorded in later years, the total estimated number of missing persons fell to 204,000. This is because during each period there were at least some age groups with apparent "excess" population, which I did not include in the total missing for that period. However in order to estimate the total number of "missing" persons from 1975 to 2000, I summed my estimates of missing persons in each intercensal period by *birth cohort* rather than by age. This ensures that some persons who left in one decade and returned in a different decade are correctly netted out from the total number of "missing." As they would likely be in a different age group by the time they returned, summing missing and excess persons by age alone would have had the unfortunate effect of showing a missing person in one age group and an "extra" person at another. That the total number of missing persons fell from 245,900 to 204,000 indicates that some of the population computed to be "missing" early on likely returned in later years, or that later population counts may have included Indonesian trans-migrants.

Using all possible combinations of my 18 different projection scenarios for 1980 with my 16 different projection scenarios for 1990 and 16 different scenarios for 2000 in this "birth cohort" method yielded a total of 18*16*16 = 4,608 different sums of "missing" persons throughout the entire period. Interestingly, the median net number of missing persons turned out to be 204,000 (±51,000),[20] quite close to what the literature has said about the total number who perished in East Timor. However, it should be noted that most of these estimates were intended to apply only to the pre-1980 or pre-1990 period, and hence may have been overestimates.

My best estimate of excess mortality in East Timor during the Indonesian occupation is 204,000 persons (± 51,000) either due to direct violence or else indirectly, perhaps as a result of hardships encountered when they were forcibly displaced by the Indonesian army. This is likely a high estimate of deaths because the number of "missing" persons most certainly contains some non-deaths (migrants, non-births, and persons not enumerated in later censuses). I have tried to factor in lower fertility rates and high numbers of out-migrants wherever possible to err on the conservative side. The Indonesian trans-migration program that brought many non-native Timorese in the 1980s and 1990s may also be disguising an even greater number of casualties.

The median results by birth cohort, shown in Figure 12, also help distinguish among losses to the population existing in 1975 and to the population born during the invasion. Population in birth cohorts after 1975 that appears to be "missing" may in fact simply not have been born due to disruptions in fertility during the invasion period. Some slight downward adjustments in the fertility rate have been made in various projection scenarios to help account for this. As Figure 12 shows, missing persons came overwhelmingly from the population that was alive at the time of the invasion. As a reminder expected mortality rates and known migration among this population has already been accounted for, so the "missing persons" shown in pre-1975 birth cohorts are likely—though not definitely—excess deaths.

Surprisingly, the birth cohorts from 1981-2000 appear to have fared quite well during the Indonesian occupation despite the fact that children are more susceptible than middle-aged

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[20] 51,000 refers to the standard deviation of the entire sample of 4,608 sums of "missing" persons. In this case it is not appropriate to provide a confidence interval over a "population" of estimates, since none were weighted by their perceived plausibility, but the sample standard deviation is included to offer a sense of the range of uncertainty.

persons to famine and disease due to forced migration. This may indicate that in fact fertility rates were higher during the invasion than previously thought, or that the Indonesian trans-migrant population was skewed toward adults with young children.
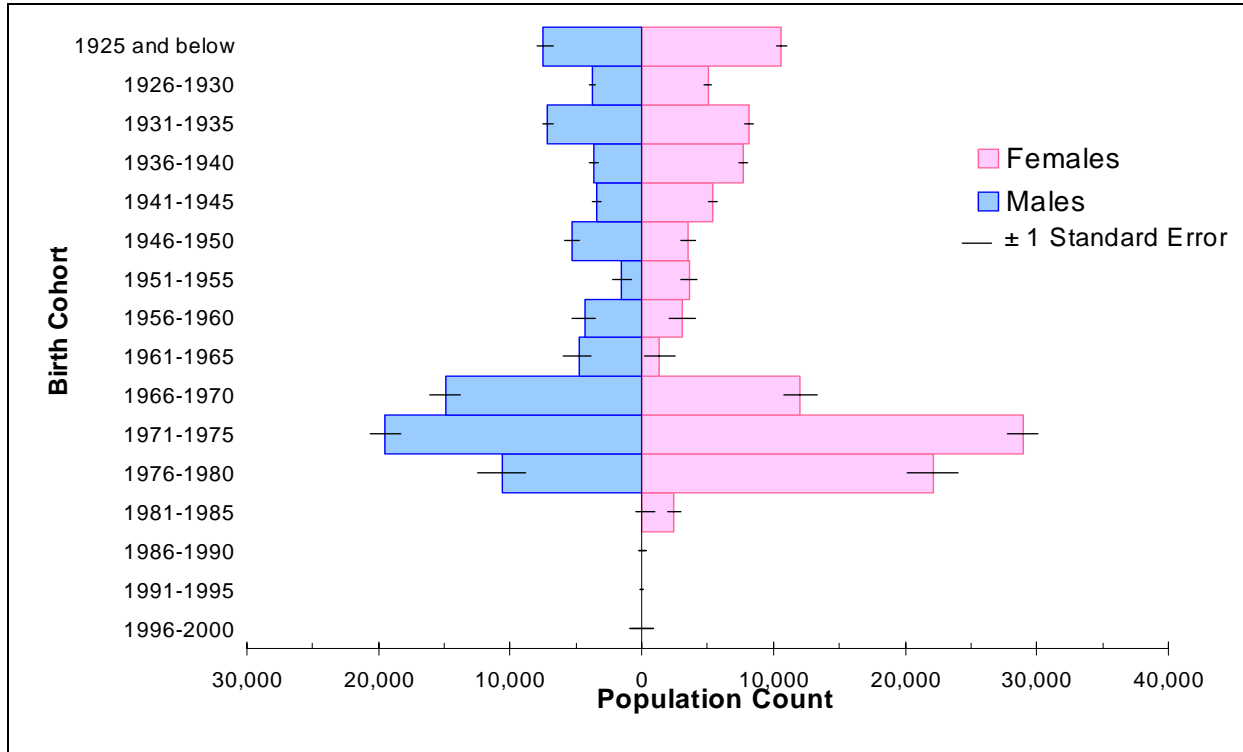
Figure 12. Median total "missing" population, 1975-2000, by birth cohort. Source: United Nations (2005) and author's calculations. Note: Birth cohort is used here instead of age in order to account for returned refugees, many of whom advanced age groups while out of the country.

Interestingly, scholars and advocates who point to the massive financial investment Indonesia made in Timorese infrastructure and population (for example, Sherlock (1996) notes that Indonesians built far more schools during their 25 years of rule of East Timor than did the Portuguese during 400 years of colonialism) and the likely resulting decreases in "natural" mortality would actually have far more excess deaths to account for than others. This is because if Timorese mortality due to "normal" circumstances were in any way decreasing during the period, in keeping with the Coale-Demeny period estimates, then projected population totals would have been much higher, along with the counts of missing persons.

The data available for calculating estimates during this historical period were not ideal, and we cannot be certain of their precision. However, we do believe this to be the best approximation of deaths possible from census data alone. The estimates produced here were for "missing" persons, which could be deaths, emigrants, or the result of unexpected decreases in fertility. Estimates from Silva and Ball (2006) were for confirmed cases of mortality. Due to the survivor bias inherent in Silva and Ball's methods, it is likely that 102,800 is a lower-bound

estimate. Silva and Ball also estimated that after accounting for recall bias, the number who died in East Timor of conflict-related deaths could be as high as 180,000. Due to the possibility that "missing" persons were not born, not enumerated, or had left, it is likely that 204,000 is a conservative upper-bound estimate on excess mortality. The "true" number of East Timorese who died because of the Indonesian occupation may never be known. This paper has, however, established the plausibility of a much higher excess death toll using only public data provided by the Portuguese, Indonesians, and the United Nations. Obvious ways to improve the estimates given here would be to incorporate information on the size and age structure of Indonesian trans-migrants and the age structure of emigrants who fled East Timor and did not return. As Waddingham (2003) suggests, it would be ideal to re-investigate original Portuguese and Indonesian census records or to more critically assess their accuracy, but this level of detail has not been made available.

Previous efforts to indirectly compute the "missing" population in East Timor simply extrapolated earlier-period population growth rates in order to surmise the number of missing persons. The estimates computed here are much more sophisticated: they indicate the age and sex distribution behind these totals, and account for changing migration, fertility, and baseline mortality during the period in order to help isolate the population that went missing due to excess mortality alone. Compared to the results published by Silva and Ball (2006), the most important advantage of these methods is that they are derived *entirely* from publicly-available data, much of it collected and published by the Indonesian government during the occupation. Hence it would be difficult for the Indonesians to claim that the large numbers of missing persons found here—especially those who went "missing" between 1975 and 1990, when the last official Indonesian census of East Timor was published—simply left or were undercounted.

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Appendix A: Leslie Matrices

A Leslie Matrix projects a population in steps that are equal to the width of its age intervals—for example, a population in five-year age groups can be projected five years ahead. We have five-year age groups and rates, but unfortunately because we want to project from 1972 to 1980 it will be necessary to convert our age groups and rates into age intervals that would allow us to project directly to 1980. In this analysis we employ five-year age intervals, which align perfectly with the dates of interest.

A Leslie Matrix is a transition matrix which is multiplied by a vector of single-sex population totals by age group to produce an age-disaggregated estimate of the single-sex population in the following period. The matrix uses single-sex mortality and fertility rates (usually for women) because fertility rates are very difficult to ascertain on a combined-sex basis. Using the ratio of women to men in the total population, this new estimate of the female population can be easily converted into a hypothetical total population estimate. The Leslie Matrix does not factor migration into account; it assumes a closed population. Migration rates can of course be added in later. According to the 1970, 1971, 1972, and 1973 Portuguese censuses, the migration in and out of East Timor was nearly equal. Hence, in the absence of additional information about migration, we assume that net migration was zero during the period.[21]

	0 to 1	2 to 3	4 to 5	6 to 7	……..
0 to 1	kids	kids	kids	kids	……
2 to 3	survivors	0	0	0	
4 to 5	0	survivors	0	0	
6 to 7	0	0	survivors	0	
8 to 9	0	0	0	survivors	
……..	……				

Figure A1. Leslie Matrix. Note: Because young girls cannot bear children, the entries in the top row of a Leslie Matrix will be zero until a column corresponding to a childbearing age group is reached. However for illustrative purposes we include "kids" (births) in the leftmost columns of the top row above.

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[21] All available information suggests that the vast majority of displaced persons stayed in East Timor and hid in the mountainous areas.

A Leslie Matrix has a top row which projects fertility and a sub-diagonal which projects survivorship (Wachter 2002). The rest of the entries in the matrix are "structural zeroes," since transitions between these groups during the time interval are impossible. Each column corresponds to an age group in the current population, while each row corresponds to an age group in the projected population, as shown in Figure A1.

It is common to refer to $A_{i,j}$ as being the entry in the ith row and j^{th} column of our Leslie Matrix. As shown in Figure A1, all of the entries in the matrix will be structural zeros except for the first row and the subdiagonal. If we assume that $_nL_x$ is the female cohort person-years lived from age x to age x+n in a hypothetical life table computed using current period age-specific mortality rates and $_nF_x^{dau}$ is the female fertility rate from age x to x+n for daughters only,[22] then the formula for the jth column of the first row is given by the following formula:

$$A_{1,j} = \frac{_nL_0}{2l_0} \cdot \left({_nF_x^{dau}} + {_nF_{x+n}^{dau}} \cdot \frac{_nL_{x+n}}{_nL_x} \right)$$

This formula allows for the fact that some women in the current age group of interest will not survive through the four-year period to bear children, and that the older women in the current age group of interest will spend most of their four-years exposed to the next age group's fertility rate. The formula also accounts for the fact that some births will not survive until the end of the four-year period.

The sub-diagonal of the Leslie matrix (an entry in $A_{j+1,j}$) is more straightforward. It simply represents survivorship among women in the current age group as they transition to the next age group. Its formula is given as:

$$A_{j+1,j} = \frac{_nL_{x+n}}{_nL_x}$$

In this project, Leslie matrices were computed separately for women and for men due to the asymmetry of their mortality patterns. Male fertility was not estimated; instead births from the female Leslie matrix were converted into a likely number of male births during the same year and added into the male Leslie Matrix before the next projection step. This unique step was taken to increase the accuracy of overall results for both males and females.

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[22] This is derived from the total female age-specific fertility rate multiplied by 0.4886, an internationally-used definition for the fraction of births which are female (Wachter, 2002).

Appendix B: Data Tables

Table B1. World population prospects population counts, 1975. Source: United Nations (2005).

Age	Females	Males	Total
0-4	54900	56500	111400
5-9	44300	46200	90500
10-14	39400	41200	80600
15-19	34100	35200	69300
20-24	29100	30200	59300
25-29	24900	26000	50900
30-34	21000	22100	43100
35-39	18500	19300	37800
40-44	15500	16300	31800
45-49	13600	14200	27800
50-54	10700	11200	21900
55-59	8700	9000	17700
60-64	5900	6200	12100
65-69	4000	4300	8300
70-74	3300	2500	5800
75+	2500	1605	4105
Total	330400	342005	672405

Table B2. World population prospects population counts, 1980. Source: United Nations (2005).

Age	Females	Males	Total
0-4	36016	41541	77557
5-9	36889	41013	77902
10-14	38031	37179	75210
15-19	38157	36684	74841
20-24	30697	31038	61735
25-29	22726	24285	47011
30-34	20201	18436	38637
35-39	16223	17554	33777
40-44	12229	14175	26404
45-49	9168	9702	18870
50-54	8100	8202	16302
55-59	4943	6015	10958
60-64	4304	3837	8141
65-69	3627	3468	7095
70-74	2034	1986	4020
75+	1799	1121	2920
Total	285144	296236	581380

Table B3. Census data population counts, 1980. Source: Bagian Statistik Demografi (1980).

Age	Females	Males	Total
0-4	30579	32021	62600
5-9	40005	43436	83441
10-14	34731	42523	77254
15-19	28215	28078	56293
20-24	27063	25078	52141
25-29	20576	21651	42227
30-34	19880	19192	39072
35-39	17545	17700	35245
40-44	14270	12776	27046
45-49	11948	11784	23732
50-54	7700	7102	14802
55-59	6280	6247	12527
60-64	5872	5600	11472
65-69	3585	4478	8063
70-74	2304	2914	5218
75+	1517	2071	3588
Total	272070	282651	554721

Table B4. Median projection population counts, 1980. Source: Author's calculations.

Age	Females	Female SE	Males	Male SE
0-4	46763	1637	48945	1564
5-9	48333	754	49761	852
10-14	40002	641	42421	794
15-19	37659	529	41932	139
20-24	30854	670	36407	395
25-29	24189	604	26075	817
30-34	22083	463	22464	417
35-39	19989	65	20627	46
40-44	18199	89	18153	204
45-49	15484	207	15642	276
50-54	12783	170	12076	83
55-59	10140	52	9907	123
60-64	8273	64	7242	185
65-69	5504	105	4953	234
70-74	3619	126	3125	251
75+	538	22	452	6
Total	343307	2086	359623	2866

Table B5. World population prospects population counts, 1990[a]. Source: United Nations (2005).

Age	Females	Males	Total
0-4	64739	68330	133069
5-9	50744	55377	106121
10-14	30962	37165	68127
15-19	33708	39002	72710
20-24	34456	35006	69462
25-29	34036	33894	67930
30-34	27032	28268	55300
35-39	19775	21809	41584
40-44	17368	16223	33591
45-49	13773	15027	28800
50-54	10158	11683	21841
55-59	7305	7568	14873
60-64	6012	5894	11906
65-69	3276	3814	7090
70-74	2404	2020	4424
75+	1492	1872	3364
Total	357240	382952	740192

a. In actual calculations these figures were reduced by 8.47 percent so as to exclude non-native households from population totals. See Hull (2003:31) for further details.

Table B6. Census population counts, 1990[a]. Source: Bagian Statistik Demografi (1990).

Age	Females	Males	Total
0-4	65379	69010	134389
5-9	51244	55929	107173
10-14	31268	37535	68803
15-19	34041	39390	73431
20-24	34797	35354	70151
25-29	34373	34231	68604
30-34	27298	28549	55847
35-39	19971	22026	41997
40-44	17540	16384	33924
45-49	13909	15176	29085
50-54	10258	11799	22057
55-59	7377	7643	15020
60-64	6071	5953	12024
65-69	3309	3852	7161
70-74	2428	2040	4468
75+	1533	1890	3423
Total	360796	386761	747557

a. In actual calculations these figures were reduced by 8.47 percent so as to exclude non-native households from population totals. See Hull (2003:31) for further details.

Table B7. Median projection population counts, 1990. Source: Author's calculations.

Age	Females	Female SE	Males	Male SE
0-4	64181	1425	67176	1492
5-9	54437	953	56538	964
10-14	32470	750	35512	1234
15-19	38507	555	42317	528
20-24	35368	622	39449	798
25-29	31122	1322	30970	1139
30-34	27531	570	26030	843
35-39	20761	345	21428	443
40-44	19035	208	17546	228
45-49	15823	239	15968	209
50-54	12090	282	11803	221
55-59	9327	336	8955	254
60-64	6648	81	5933	134
65-69	4117	147	4101	88
70-74	2962	162	2405	159
75+	422	16	408	23
Total	375671	5272	387502	5716

Table B8. World population prospects population counts, 2000. Source: United Nations (2005).

Age	Females	Males	Total
0-4	49026	51086	100112
5-9	53342	55678	109020
10-14	57842	61701	119543
15-19	41478	48292	89770
20-24	13217	23512	36729
25-29	12829	22376	35205
30-34	17261	20916	38177
35-39	21395	23081	44476
40-44	18244	20219	38463
45-49	13764	15795	29559
50-54	12842	11633	24475
55-59	10213	10851	21064
60-64	7235	7970	15205
65-69	4771	4555	9326
70-74	3442	3011	6453
75+	2226	2029	4255
Total	339127	382705	721832

Table B9. Median projection population counts, 2000. Source: Author's calculations.

Age	Females	Female SE	Males	Male SE
0-4	44458	1236	46532	1293
5-9	44178	1120	45846	1176
10-14	45140	1124	47162	1189
15-19	35850	921	39098	1005
20-24	21236	595	25973	674
25-29	22520	685	26505	733
30-34	23261	653	23069	713
35-39	23131	617	22406	658
40-44	18192	488	18689	520
45-49	13126	356	14031	405
50-54	11256	313	10115	295
55-59	8687	238	8956	261
60-64	6097	166	6487	191
65-69	3861	129	3630	133
70-74	2555	130	2212	125
75+	275	14	285	16
Total	323823	8546	340997	9118

Table B10. Median estimate of "missing" population, 1975-2000, by cohort. Source: Author's calculations.

Birth Cohort	Females	Female SD	Males	Male SD
1996-2000	0	1024	0	1162
1991-1995	0	0	0	0
1986-1990	0	1532	0	1164
1981-1985	-2431	3810	0	1975
1976-1980	-22119	7124	-10603	7694
1971-1975	-28924	4759	-19534	4564
1966-1970	-12043	4664	-14925	4836
1961-1965	-1349	3890	-4798	4734
1956-1960	-3027	2850	-4300	4001
1951-1955	-3614	3322	-1606	2488
1946-1950	-3505	2129	-5328	2308
1941-1945	-5398	1318	-3452	1319
1936-1940	-7694	1496	-3665	1184
1931-1935	-8171	1761	-7149	1371
1926-1930	-5002	676	-3769	970
1925 and below	-10596	3311	-7539	1439
Total	-116496	25600	-88625	24490

Table B11. Sample female Leslie Matrix used in projections from 1975 to 1980. Source: Author's calculations.

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
0-4	0	0	0.0586	0.2759	0.5095	0.5611	0.4195	0.2122	0.104	0.0454	0	0	0	0	0	0
5-9	0.9621	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-14	0	0.9728	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-19	0	0	0.9623	0	0	0	0	0	0	0	0	0	0	0	0	0
20-24	0	0	0	0.9238	0	0	0	0	0	0	0	0	0	0	0	0
25-29	0	0	0	0	0.9217	0	0	0	0	0	0	0	0	0	0	0
30-34	0	0	0	0	0	0.9488	0	0	0	0	0	0	0	0	0	0
35-39	0	0	0	0	0	0	0.9392	0	0	0	0	0	0	0	0	0
40-44	0	0	0	0	0	0	0	0.938	0	0	0	0	0	0	0	0
45-49	0	0	0	0	0	0	0	0	0.9237	0	0	0	0	0	0	0
50-54	0	0	0	0	0	0	0	0	0	0.9112	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0	0	0	0	0.9021	0	0	0	0	0
60-64	0	0	0	0	0	0	0	0	0	0	0	0.8682	0	0	0	0
65-69	0	0	0	0	0	0	0	0	0	0	0	0	0.7621	0	0	0
70-74	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6406	0	0
75+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0

Table B12. Sample male Leslie Matrix used in projections from 1975 to 1980. Source: Author's calculations. Note: Male Leslie Matrix applies only to mortality; newborn males estimated as a fixed ratio of newborn females after using the female Leslie Matrix.

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
0-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-9	0.9494	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-14	0	0.9701	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-19	0	0	0.9642	0	0	0	0	0	0	0	0	0	0	0	0	0
20-24	0	0	0	0.9575	0	0	0	0	0	0	0	0	0	0	0	0
25-29	0	0	0	0	0.9226	0	0	0	0	0	0	0	0	0	0	0
30-34	0	0	0	0	0	0.9077	0	0	0	0	0	0	0	0	0	0
35-39	0	0	0	0	0	0	0.9346	0	0	0	0	0	0	0	0	0
40-44	0	0	0	0	0	0	0	0.9182	0	0	0	0	0	0	0	0
45-49	0	0	0	0	0	0	0	0	0.9025	0	0	0	0	0	0	0
50-54	0	0	0	0	0	0	0	0	0	0.8882	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0	0	0	0	0.8624	0	0	0	0	0
60-64	0	0	0	0	0	0	0	0	0	0	0	0.8255	0	0	0	0
65-69	0	0	0	0	0	0	0	0	0	0	0	0	0.7151	0	0	0
70-74	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5871	0	0
75+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1419	0