Mortality analysis for Tonga, 1982-1992

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Abstract

This study examines the mid-decade mortality data from Tonga for 1982-1992. It aims at determining the plausibility and usefulness of the information obtained from analysing routinely collected mortality data for planning purposes.

It examines the mortality data in a- two-time period analysis; the first period refers to 1982-86, and 1987-92 is the second period. For the first period, mortality statistics were tallied from the Vital Registration Record, which are collected under the auspices of the Ministry of Justice, and compared with the mortality data derived from 1986 Population Census. For the second period, 1987-92, the mortality data tallied from Vital Registration record was compared with those from the Health Information and Computing System of the Ministry of Health, and also with those from other sources like South Pacific Commission, WHO, World Bank, United Nation Development Projects and UNICEF.

The mortality statistics were adjusted for under-enumeration of registered deaths from the Vital Registration, using the Brass Growth Balance Method. For 1982-86, the registered deaths were under-enumerated by 34% for males, and 29% for females. Using the United Nations General Model Life Tables to produce a Life table for Tonga, the following demographic values were obtained. Life expectancies at birth was 66 years for males and 70 years for females with an adjusted infant mortality rate of 28/1000 male live births and 23/1000 female live births, giving an infant mortality rate for Tongans of 26/1000 live births. The overall adjusted crude death rate was 6/1000 population years. The above demographic values were comparable with those obtained from the 1986 Population Census.

For the 1987-92 period, the under-enumeration of registered deaths obtained from the Vital Registration improved to an estimated 23% for males and 20% for females, according to the Brass Growth Balance Method.

From the United Nations General Model Life Table for Tonga, life expectancy at birth for males averaged at 68 years and for females' 72.0 years. The infant mortality rate was 24/1000 male live- births and 22/1000 female live-births, giving an infant mortality rate for Tonga for the period 1987-92 of 23/1000 live births. An adjusted overall crude death rate was 5/1000 population years. Comparing the mortality statistics from this study with values from other sources indicate that the routinely collected mortality data in Tonga can be analysed to produce plausible, updated and useful information for planning purposes.

Introduction

The division of distinctive cultures and societies within the Pacific are based on their social organisation and material development. They are basically divided into three main races: The Big Men of Melanesia', occupying the islands of the western Pacific, south of the equator; the 'hereditary dynasties of the Polynesians' to the east; and the 'localised hierarchy of Micronesia', occupying the islands to the west of the equator[1,2] Tonga belongs to the Polynesian group, and, today remains the only Kingdom within the Pacific nations.

Tonga consists of about 150 islands but only 36 are inhabited. The group is divided into 4 main island groups, namely Tongatapu the main island and 'Eua, Vava'u, Ha' apai and the Niuas. The archipelago covers an area of about 700 km^2 between 15 - 23.5° S, 173 - 177° W.

Mortality and related information on Tonga

Population and mortality levels from ancient days are but estimates based on archaeology, early writings and legends. It is claimed that the closest estimate of mortality from early periods was archaeologists' findings at the burial place at 'Atele, about 7 km east of the capital, Nuku'alofa. The evidence signified that death was very common in children below 5 years of age, and about 'half of the children died before they reached that age', and there were fewer teenage deaths, and few people reached the age of 40

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Table 1. Population of Tonga by sex and growth rate at census since 1900

	Population			Increase since previous census		
Census dates	Males	Females	Total	Males	Females	Total
1901 - 31 Mar			20,700			
1911 - 03 Apr	11,951	11,066	23,017			317
1921 - 26 Apr	12,980	11,955	24,935	1,029	889	1,918
1931 - 27 Apr	14,089	14,750	28,839	1,109	2,795	3,904
1946 - 01 Oct	17,617	16,513	34,130	3,528	1,763	5,291
1956 - 26 Sep	28,938	27,900	56,838	11,321	11,387	22,708
1966 - 30 Nov	39,837	37,592	77,429	10,899	9,692	20,591
1976 - 30 Nov	46,036	44,049	90,985	6,199	6,457	2,656
1986 - 28 Nov	47,611	47,038	94,649	1,575	2,989	4,564

Source. South Pacific Commission, 'Statistical Bulletin of the South Pacific No. 42' Noumea, New Caledonia, 1994

years[1]. Though the number studied from this burial ground may be small, the mortality pattern was similar to that found in Europe and other parts of the Pacific in medieval days.

According to the Vital Registration (V/R) office, vital events' registration started in 1867. Population censuses have been regularly conducted since 1891. Censuses were performed every ten years until 1931, and then there was none until 1956 to date.

The mortality estimates based on the 1939 Population Census gave an estimated life expectancy at birth of 40 years for Tongans with an infant mortality rate (IMR) of 180/1000 live births [3], However, around 1950s the IMR was around 89/1000 live births. The factors that considered likely to influence the improvement of IMR within that 11-year period might be the quality of collected data, method of analysis and socioeconomic factors.

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The population of Tonga was estimated to be 30,000 prior to European contact in the 1600s, with 18,000 at Tongatapu [1,4], About 3.5 centuries later in 1956, the population census reached 56,838. Even though there was no specific policy to keep the population down, there were civil wars and recorded epidemics that wiped out a large proportion of the population. For example: In 1893, an epidemic of measles killed an estimated 1,000 people which was about 5% of the whole population of Tonga [1,5]. So, it was those factors that helped to explain why the population of Tonga was just started to pick up by mid-century as shown by the population census in 1956 (Table 1).

A published infant mortality retrospective study done in Tonga, 1969-79, described four different values and different trends for the IMR[6] For 1976, the year of the Population census, the IMR was 28/1000 live births (Health Department, 1976), 16/1000 live births (Health Department-total), 15/1000 live births (Justice Department-total) and 13/1000 live births (1976 Population Census). The trend for the four sets of IMR 'was increasing with a tendency to come together after 1975'[6] This reflected the sort of information that has been available to the decision-makers a decade and a half ago. One wonders whether the decision-makers realised that this was the sort of information that was being produced from the data that they were annually collecting. But since 1983 there has not been any published information on mortality specifically for Tonga based on non-census data collection. However by 1987 an analysis was published based on routinely collected data to assess the utilisation of hospital's Outpatient or Casualty Departments after building new health centres[7]. The outcome from that study supports the fact that the routine collected data could give a reasonable guide to planning, but with careful interpretation. However, evidence to date shows that Tonga information system, especially that of Health and Vital Registration (under the auspices of Justice Department) are still 'in search of a future'[7] in terms of proactivity and efficiency[8].

Even though the most recent Population Census for Tonga was performed in 1996, its full analysis is still on the process. Thus the last Population Census before this study was on 28th November 1986[9] The 1986 Census estimated a total population of 94,649, with 67% (63,415) residing in Tongatapu, 16%(15,144) in Vava'u, 9%(8,579) in Ha'apai, 5% (4,732) in Eua and 3% (2,840) in the Niuas. There was 98.3%

Tongan and part-Tongans, while 1.5% was non-Tongan, and 0.2% did not state their ethnicity. The age distribution showed that 40.6% (38,442) of the whole population were less than 15 years, 55.1% (52,152) aged between 15-64 years, and 4.3% (4,194) were 65 years and over [9 13].

Mortality information from the 1986 Population Census included estimates of an Infant Mortality Rate (IMR) of 26.0/1000 Tongan live births, and under 5 years of age mortality rate (UFM) of 31/1000. An average Tongan female and male were expected to live (life expectancy at birth) an average of 70.7 years and 67.6 years respectively. The demographic figures were derived from Coale and Demeny life table, after combining the estimated child mortality with the adult mortality using the (COMBIN) technique of the Mortpak Lite[14] program.

The overall crude death rate was 5.6 per 1000 population-years. The quality of data collected in the 1986 Population census was good according to the Child Ever Born Child Surviving (CEBCS) technique of the UN Mortpak- Lite program. However, evidence to date shows that Tonga's information system, especially that in Health and Vital Registration (under the auspices of the Justice Department), are still 'in search of a future', in terms of pro-activity and efficiency[2,7,8].

There are numerous writings from different sources, local, regional and international, which include mortality information on Pacific Islands, including Tonga. Many of these sources basically do their analysis and presentation based on data and information from surveys and censuses sent in from respective countries. Occasionally, what the organisations present causes concern because of the implausibility nature of data produced, and that can be misleading. For example, a table of contradictory demographic values presented by WHO[15] and UNICEF and UNDP[16] for countries of the Pacific region around the same period of time. That is, UNICEF and UNDP presented an IMR of 26/1000 live births for Tongans while WHO presented an IMR of 9.8/1000 Tongan live births. It seems that UNICEF and UNDP might have used data from the 1986 Population Census, while WHO might have got its information from the Ministry of Health. An IMR of 9.8/1000 live births for Tonga is implausible, considering factors like completeness of collected data, method of analysis, credibility of analysed information, and other related socioeconomic indicators. Accepting and printing values like that from a well-respected source can be misleading in many ways. For example the local health authority may have the false impression that what they have done is so good that to reduce IMR further is no longer a top priority for activities. On the other hand, donor agencies looking at such IMR value might consider withdrawing much needed aid and funds from the country. However one would like to think that if implausible values were supplied from a country, not only would a re-confirmation be called for, but moreover, that clearly indicate that there is a need for assistance in the area of data and information analysis from that country supplying such information. However, occasionally there may not be an update information sent to such organisations and they tend to extrapolate from old and out-of-date data which also can be misleading. Such action only signifies that even the big and powerful organisations are not always correct, and are not fallible[17].

The Population censuses for Tonga have provided the best and the most reliable base for estimating demographic values like IMR and mortality rates by sex and age, life expectancies and crude death rate for the inter-censal periods. However, throughout every year in Tonga, both Vital Registration (V/R) and the Health Department collect mortality data and information. These data could provide some useful information if requested and used. But, if not those data would not be utilised, and remained in the 'cemetery'[2] indefinitely.

Therefore, this study was undertaken to see whether the routinely inter-censal collected mortality data be analysed to produce a timely, plausible and useful information for planning purposes for Tonga. It should also provide some insight into why and how our Information systems be improved towards pro-activity and efficiency in future. Specifically, this study aims at:

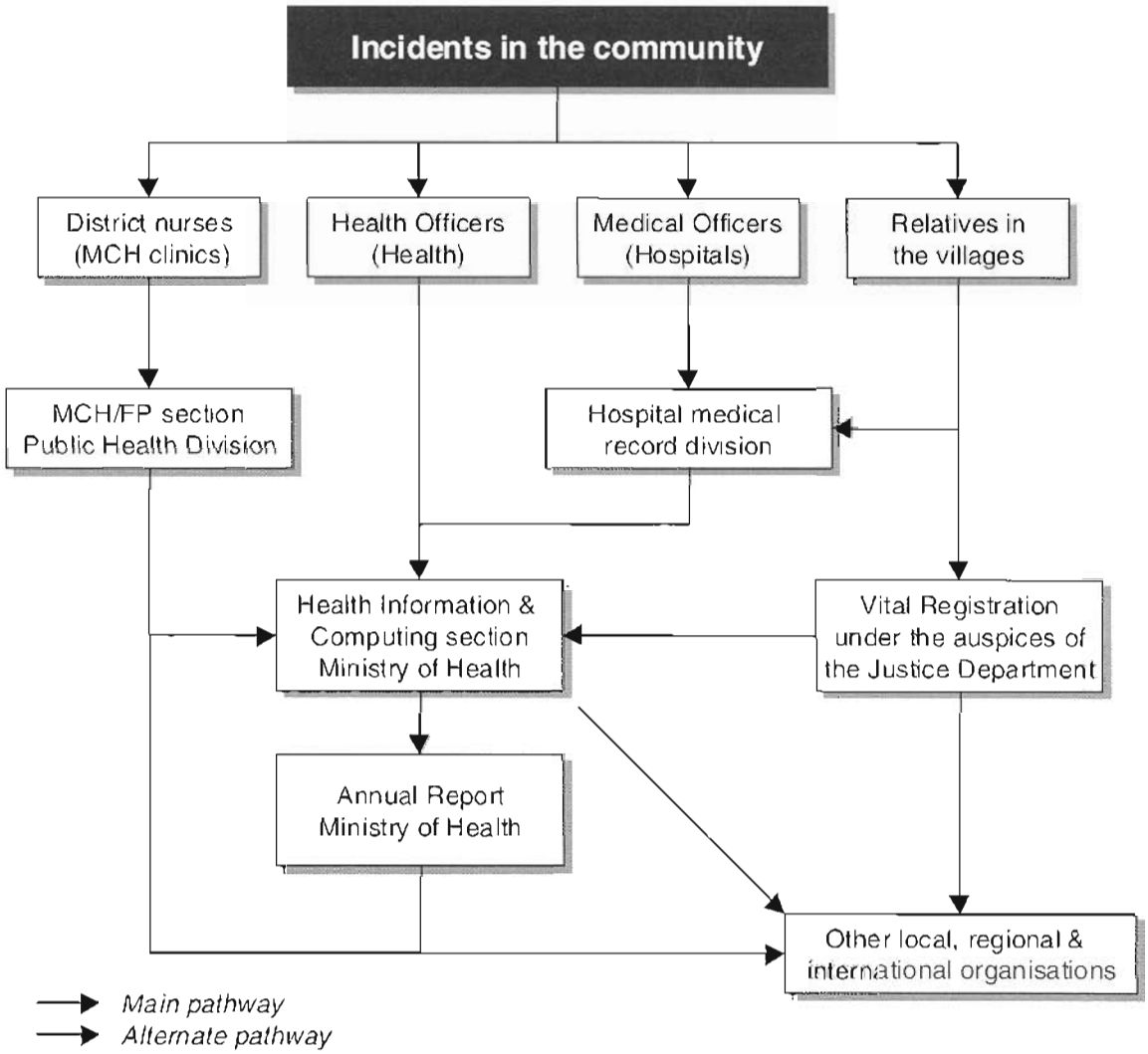
... evidence to date shows that Tonga's information system, especially that in Health and Vital Registration..., are still 'in search of a future', in terms of pro-activity and efficiency.

a) Assessing the completeness of the mortality statistics produced by the Vital Registration and the Health Department;
b) Determining the total mortality rates by sex and age brackets from all causes, and life expectancies, for 1982-86 and 1987-92;
c) Comparing the 1982-86 mortality data with the mortality estimates produced from the demographic analysis of the 1986 Population Census, and 1987-92 mortality analysis with values produced from other sources;
d) Assessing the plausibility of the information from this analysis using the routinely collected mortality data by comparing it to those produced from various sources.

Materials and methods

Sources of mortality data. The main mortality records identified were the Vital Registration (V/R) records, which is under the auspices of the Ministry of Justice, and the Health Information and Computing System (HICS) of the Ministry of Health. Other records which were also looked into included:

Fig. 1. Pathways taken by a vital event to get to the central record



Adapted from Finau 1982

medical charts of the deceased, copies of death certificates, church burial records and the Statistical Abstracts from the Government Statistic Department.

The medical charts of the deceased were impossible to locate at the time, mainly because the medical record section was being re-arranged and re-located, and the deceased charts were not yet properly organised. There were incomplete copies of death certificates available, but some especially from the outer islands were not found. The burial records of the churches, especially the two main denominations, the Methodist and the Roman Catholic, should be good, since it is customary in Tonga to give every deceased person a burial service. However, the records were not properly organised, and there is no central record collection, and therefore it was not possible to use them.

Mortality information from regional and international sources, like the South Pacific Commission (SPC), World Health Organisation (WHO), World Bank and UNICEF were examined. These sources give very good summaries of demographic and health indicators on Tonga which will be used for comparison with the outcome of this analysis.

The two main data sources. The central office for the VIR and the HICS are situated at Nuku'alofa, the capital. The vital events in the outer island groups arrive at these centres in a summary form, and all particulars were entered as they appear on the death certificate. How a vital event in the community is reported to these centres is as illustrated (Figure 1).

All episodes are entered according to the year of death, and in the sequence of when the death certificate arrived in the recording office. The VIR record does not record the cause of death. Commenting upon the reason for not recording cause of death, the V/R officer in charge stated that cause of death refers to disease, and disease is the

concern of the Health Department and not the V/R. The other reason could be that the V/R does not receive data from the health officer or from the field workers directly. On the other hand, the staff at the HICS admitted to the likelihood that their register was not complete, but stated that the V/R should be better as recording vital statistics was their primary job. Apparently, the V/Rand the HICS have different reasons and motives for what to record, and how they did it.

However, concerning the issuance of death certificate, the VIR and the Health information and computing section of the Ministry of Health are liaising for revalidation of their record. The relationship between these two main sources of mortality data is not very clear, but there is reason to believe that the vital statistics collected by these two sources are moving towards reconciliation. In 1989, all deaths, whether in or outside of hospital, were to be certified by a qualified medical doctor, according to verbal direction from the then Chief Superintendent of hospitals. This kind of practice would definitely affect the record of cause of death, especially for those who died outside of hospital.

It was of interest to note that in 1990, total deaths tallied from both main sources were exactly the same. However, going through individual deaths by age group and sex, it was found that they were not distributed exactly the same way. The distribution according to age and sex were more similar in the younger age group (<15 years), while deaths of older age groups displayed marked differences in number. For example, there were 31 more deaths in the Health dataset in males 55-64 years of age compared to VIR record. This could reflect the possibility that older people tend to exaggerate their ages much more than younger ones, or was it they give older ages to one source compared to the other.

Enumeration of deaths

A. From Vital Registration record. In the Vital Registration records there were numerous corrections in the form of crossing-off re-allocation of new numbers to names previously recorded, referring a name to a new page, liberal use of white liquid paste, and rewriting of a different name on top of another name.

Each year was tallied by sex and by 5-year age brackets for 1982-92. The tally was complicated by the fact that every person, regardless of age and sex, was entered in the sequence of the arrival in the office of their death certificate. Since sex was not indicated, specific female and male names helped to identify the sex of the person, but unfamiliar foreign names made the task slower. For the date of birth column, some entries contained no birth date, but an estimated age in years and months only. Thus ages were recorded according to what appeared in the columns. The total tallied was different from that indicated by the sequence numbers. This could be due to too many corrections which caused confusion with the numbers.

B. From Health Department's record. Deaths recorded were from 1988-92. Prior to 1989, deaths of in-patients only were presented in the Annual Health Minister s reports. However, from 1988-89 only the detailed computer printouts of mortality information were available. Deaths for the rest of the studied period, 1990-92, were obtained from the Annual Reports of the Minister of Health. All deaths were tallied by sex and 10 year age brackets for 1988-92.

Calculation of mid-year population

The population of Tonga in various age and sex brackets was estimated from calculations based on 1976 and 1986 Population censuses. The values for the estimated population of 1982-85 was linearly interpolated between 1976 and 1986 Population censuses. For the population of 1987-92, estimates were based on extrapolation from the 1986 Population census, using the annual growth rate of 0.2 % obtained from the Labour Force Survey[18], as the multiplication factor. The annual growth of 0.2% from 1986 to 1990 is very possible given the extensive out-migration evidenced in Tonga's situation. This low annual growth was supported from the MCH nurses' annual census of headcounts for the years 1991 and 1992[19] Also, between 1986-87, the Demographic Year-Book for the Pacific recorded approximately 5000 Tongans leaving to New Zealand[20] However, on the other hand there is still the possibility that the 0.2% annual growth between 1986 and 1990 LFS could be an under-estimate.

The mid-year population for each year was estimated for sex and age brackets by averaging the end of the year population for the two-period studied. The sum of the mid-year population for each sex and age bracket was used as the denominator for the calculation of the aggregated death rates for all study years. For the IMR, aggregated live births for the study periods were the denominator.

Total Mortality Rates and life expectancy

Total tallied deaths from all causes for 1982-92 from Vital Registration record (VIR) and Health record were used to construct abridged life table according to the method described by Pollard[21] and Palmer[22]. Mortality data derived from the VIR were divided into a two-time-period for analysis, that is, from 1982-86 and from 1987-92. The graphs for age specific death rates for males and females for the two-time period were plotted on natural logarithmic scales.

The difference between the unadjusted and the adjusted values for age-specific death rates for males and females in 1982-86 and 1987-92 were observed.

Table 2. Deaths, populations and mortality rate per 1000, by age and sex for all Tongans, 1982-86*

	Age group	< 1	0 - 4	0 - 14	15 - 44		45 - 64		0 - 65+		Combined
	Sex	M + F	M + F	M + F	M	F	M	F	M	F	CDR
1982	Deaths	17	34	47	33	20	58	22	234	190	
	Populatio	2,511	13,295	39,160	19,317	19,528	5,497	5524	46,902	45,609	
	Rates	6.7	2.6	1 2	1 7	1.0	10.6	4.0	5.0	4 2	4.6
1983	Deaths	19	35	44	34	25	65	44	230	170	
	Populatio	2,552	13,434	39,002	19,470	19,732	5,546	5,629	47,060	45,992	
	Rates	7.4	2.6	1 1	1.7	1 3	11.7	7.8	4.9	3.7	4.3
1984	Deaths	9	14	21	27	16	67	37	186	124	
	Populatio	2,592	13,572	38,842	19625	19,732	5,596	5,732	47,217	46,291	
	Rates	3 5	1.0	0.5	1.4	0.8	12.0	6.5	3.9	2.7	3.3
1985	Deaths	17	25	41	28	15	66	44	218	160	
	Populatio	2,633	13,709	38,681	19.799	20,144	5,644	5,893	47,375	46,590	
	Rates	6.5	1.8	1.1	1.4	0.7	11.7	7.5	4.6	3.4	4.0
1986	Deaths	13	21	31	23	16	72	53	210	137	
	Populatio	2,673	13.638	38,548	19,932	20,347	5,693	5.940	47,532	46,889	
	Rates	4 9	1.5	0.8	1.2	0.8	12.6	8.9	4.4	2.9	3.7

** Populations = mid year population. M = males, F = females, CDR = crude death rate*
Source: Vital Registration, under the auspices of Justice Department, Tonga.

The initial mortality life tables were adjusted for under-enumeration by adopting the Brass Growth Balance method[23] To use this method, certain assumptions are invoked which includes the:

- assumption of population stability;
- assumption of constant completeness of death registration by age;
- assumption of closed (to migration) population;
- assumption of accuracy of age reporting.

Some of those assumptions may not be valid for this study, but the basic assumption is that the proportion of under-registration of deaths is constant throughout the ages. Such an assumption is not plausible since the proportion of deaths in the young and old age groups are usually more under-registered than those in the adult age range. Adjustment of this nature is best for adult mortality[23,24]. Using the Brass technique, values for the partial death rate and partial birth rate for each sex and age were plotted on a natural logarithmic scale graphs.

If the plots of partial birth and partial death rates give a linear plot, it signifies that the Brass method can be used on Tonga's mortality data. A line of best fit was fitted, and the slope of the line was calculated by linear regression. From this value, the percentage of completeness of the death registration can be obtained, and its reciprocal is the correction factor. The correction factor was used to inflate the number of deaths for all age groups before new abridged life tables were constructed. Deaths of people in the older age groups constitute a large proportion of the total deaths, therefore they weigh more heavily on the determination of the slope of the line of best fit.

From the abridged life tables, age-specific death rates for the infants and childhood were suspicious as they seemed too low to be plausible, and also in relation to what was expected from adult mortality as in model life tables. This suspicion, plus the fact that the Growth Balance Brass method of adjustment is best mainly for estimates of adult mortality rates, the program COMB IN of the United Nations Mortpak-Lite was used to combine the estimated child mortality with the adult mortality to produce life tables. From these life tables, estimated values for IMR and life expectancies at different ages and for different sexes in the two-timed period studied were obtained.

For the study periods of 1982-86 and 1987-92 respectively, complete mortality life tables by sex and age were produced. The probability of dying (qx) in childhood were first estimated from the third component of the United Nation best-fit (BESTFT) program in the Mortpak Lite based on adult mortality data.

These values of qx in the childhood deaths were combined with the probability of dying in the adults by using COMBIN program of the Mortpak Lite, adopting the WEST model of Coale and Demey, to produce the mortality life tables for Tonga for the studied periods. These tables were used as the final data for male and female IMR and life expectancies at birth and other ages.

Another method of calculating the IMR looked at was the Boeckh method[25]. This method involves calculation of the IMR from the probability of dying within the first year of life by considering the deaths that actually occurred in each cohort of births. The estimated IMR for the study period of 1988-92 obtained when using that method was 15.6/1000 live births. This value looked low, and because it was lower

Table 3. The Brass method of adjustment for under-enumeration of Tongan female deaths for 1982-86

Exact age y	Population at age y and over	Reported deaths at age y	Population at exact age y	Partial death rate	Partial birth rate	Adjustment factor for under-enumeration*
(y)	(py)	(dy)	(ny)	(dy/py) (x-axis)	(ny/py) (y-axis)	
0	231,239	746				*Constant = 0.0395*
1	224,894	709				*Std Err of Y Est = 0.0010*
5	198,424	689	6,449	0.0035	0.0325	*R Squared = 0.9951*
10	166,754	684	6,070	0.0041	0.0364	*No. of Observations = 3*
15	137,727	674	5,761	0.0049	0.0418	*Degrees of Freedom = 1*
20	109,149	662	4,972	0.0061	0.0455	*X Coefficient(s) = 1.4104*
25	88,012	652	3,631	0.0074	0.0413	*Std Err of Coef.= 0.0801*
30	72,837	642	2,853	0.0088	0 0392	*Estimated enumeration = 71.0%*
35	59,479	636	2,466	0.0107	0.0415	
40	48.178	614	2.144	0.0127	0.0445	
45	38,038	582	1,937	0.0153	0.0509	
50	28,808	553	1,721	0 0192	0.0597	
55	20,833	512	1.459	0 0246	0.0700	
60	14,223	454	1,146	0.0319	0.0805	
65	9,378	382	848	0.0407	0 0905	
70	5,740	301	600	0.0524	0.1045	
75	3,380	216	574	0.0639	0.1698	

** X coefficient = slope of line. Constant = growth rate. Reciprocal of X coefficient = correction factor*
Source: Vital Registration, under the auspices of Justice Department, Tonga.

in comparison to those obtained from the mortality life tables, it was decided to use the IMR values from the mortality life tables for the rest of the analysis.

Results

A. 1982-1986 Mortality. The total deaths from all causes for Tongans from the Vital Registration (V/R), under the auspices of the Justice Department for 1982-86 was 1859; 58.0% were males and 42.0% were females. The average crude death rate was 4.0/1000 population-years.

The logarithmic graphs of partial death rate and partial birth rate for age for males and females for 1982-86 showed reasonable linear plots. The line of best fit was fitted and the percentage of completeness of death registration which is the reciprocal of the X coefficient, was calculated from the slope of line by linear regression. Deaths enumerated for all males and females for Tonga for 1982-86 from the Vital Registration (VIR) was under-enumerated by 3 .0%, according to the Brass Growth Balance method. (See Table 2)

The male deaths for 1982-86 from the VIR recorded an estimated enumeration of 66.3% of the total estimated deaths for the period; while for females, only 71.0% of the total estimated deaths were registered according to the Brass method (See Tables 3 and 4).

The X coefficients were used to inflate the recorded deaths enumerated from the Vital Registration for 1982-86 according to the Brass technique of adjustment, to produce new abridged life tables for Tonga for the period. After using the Brass method for adjustment of under-enumeration then applying the General Standard of UN Model Life Table on data from the Vital Registration, life tables for Tonga for the period 1982-86 were produced (See Table 5).

Thus from the adjusted model life tables, it estimates an IMR of 28.3/1000 male live births, and 23.4/1000 female live births. Therefore an adjusted IMR for Tongans during the study period of 1982-86 was about 25.9/1 000 live births. During the same period, 1982-86, males were expected to live an average of 66.3 years from birth while for their female counterparts was an average of 69.5 years. Overall, Tongan females outlive the Tongan males at birth by 3.2 years. At the age of 20 years, males were expected to live an average of 49.4 more years, and females an average of 52.3 years. Thus females live longer than their male counterparts when they reach the age of 20 years by an average of 3 more years.

B. The 1987-1992 Mortality. It must be noted that the methods and procedures used for the analysis of the period, 1982-86, was the same as that used for 1987-92 study period analysis.

Table 4. The Brass method of adjustment for under-enumeration of Tongan male deaths. 1982-86

Exact age	Population at age y and over	Reported deaths at age y	Population at exact age y	Partial death rate	Partial birth rate	
(y)	(py)	(dy)	(ny)	(dy/py) (x-axis)	(ny/py) (y-axis)	Adjustment factor for under-enumeration
0	235884	1063				
1	229269	1011				*Constant = 0.0185*
5	200841	981	6887	0.0049	0.0343	*Std Err of Y Est = 0.0004*
10	167016	964	6565	0.0058	0.0393	*R Squared = 0.9998*
15	135188	943	6288	0.0070	0.0465	*No. of Observations = 3*
20	104138	914	5289	0.0088	0.0503	*Degrees of Freedom = 1*
25	82298	891	3632	0.0108	0.0441	*X Coefficient(s) = 1.5091*
30	67823	864	2617	0.0127	0.0386	*Std Err of Coef. = 0.0203*
35	56126	851	2150	0.0152	0.0383	***Estimated enumeration = 66.3%***
40	48323	826	1906	0.0178	0.0412	
45	37065	797	1776	0.0215	0.0479	
50	28560	743	1628	0.0260	0.0570	
55	20782	692	1442	0.0333	0.0694	
60	14142	600	1169	0.0424	0.0827	
65	9089	479	888	0.0527	0.0977	
70	5261	357	637	0.0679	0.1210	
75	2723	244	526	0.0896	0.1932	

** X coefficient = slope of line. Constant = growth rate. Reciprocal of X coefficient = correction factor*
Source: Vital Registration, under the auspices of Justice Department, Tonga.

The registered deaths from the Health Department's record for the period of 1988-92 accounted for only 66.7% of the estimated total deaths for males and 56.9% for the females, according to the Brass Growth Balance method[23]. On the other hand, the total estimated enumerated deaths for all Tongans from the Vital Registration for 1987-92 was 77.3% complete for males while for females it was 80.0% complete (Table 6). Because of better registration of deaths for Tongans by the Vital Registration, the author decided to use the Vital Registration mortality data for the rest of the analysis.

For the period of 1987-92, the registered total deaths from all causes tallied for Tongans was 2,595 with 51.9% males and 48.1% females. The overall crude death rate was 4.6 per 1000 population-years. After using the Brass technique[23] for adjustment of under-enumeration, the X-coefficients were used to inflate deaths enumerated from the Vital Registration records to produce new abridged life tables for Tongans, 1987-92.

The plots of age-specific death rates for males and females on logarithmic scales did not show much difference between adjusted and unadjusted age-specific mortality rates curves for both males and females. The fact that both female deaths and males' were almost equally registered (80.0% and 77.3%) may be the explanation. The registered deaths from all causes accounted for 78.0% of the total estimated deaths for 1987-92, according to the Brass method of adjustment for under-enumeration.

Mortality life tables for the period 1987-92 were constructed using the General Standard of the United Nations Model life table method after using the Brass technique (Table 7). Demographic indicators produced from this analysis were: a life expectancy at birth for males was estimated to be 68.1 years and females was 72.0 years, and by the age of 20 years, females outlive their male counterparts by 3.9 years. An adjusted IMR was 23.9/1000 male live births and 21.8/1000 female live births, therefore for the period 1987-92, IMR was 22.9/1000 live births. The adjusted total crude mortality death rate was 6.0 per 1000 man-years and 4.9 per 1000 woman-years, thus giving an adjusted overall crude death rate of 5.4 per 1000 Tongan-years.

Discussion

Mortality data analysis tends to have its own borders, which make it often hard to pinpoint which are the most appropriate and suitable as the objects of prevention. Mortality data is just one of the tools to determine the relative magnitude of different health problems and their

Table 5. Estimates of death rates and expectation of life for Tongans, by age and sex, 1982-86*

	Females		Males	
Age	Age specific death rate per 1000	Expectation average length of life from age x	Age specific death rate per 1000	Expectation average length of life from age x
Years	(mx)	(ex)	(mx)	(ex)
0	0.0234	69.5	0.0283	66.3
1	0.0011	70.1	0.0015	67 2
5	0.0010	66.4	0.0009	63 6
10	0.0007	61.8	0.0007	58 8
15	0.0012	57 0	0.0014	54.0
20	0.0017	52.3	0 0018	49.4
25	0.0021	47.7	0 0020	44.8
30	0.0024	43.2	0.0023	40.2
35	0.0030	38 7	0.0031	35 7
40	0.0039	34 2	0.0046	31.2
45	0.0054	29 9	0.0071	26.8
50	0.0078	25.6	0.0113	22 7
55	0.0115	21.5	0 0175	18 9
60	0 0180	17.6	0.0268	15.3
65	0.0292	14.1	0.0418	12.2
70	0.0488	10.9	0.0659	9.5
75	0.0811	8.2	0.1025	7.2
80	0.1658	6	0.1842	5.4

* *Obtained from Mortality life table after adjustment for under-enumeration (Brass technique) and Projection onto model life table Particularly for correction of infant and childhood mortality.*
Source: Vital Registration, under the auspices of Justice Department, Tonga.

related social impacts and vice versa. Mortality statistical analysis as from the context of this paper provides partial insight to the health situations in Tonga. At the same time it presents challenges for the information system and implications on need of research skills to those involved, especially in the Health Department and Vital Registration, under the auspices of Justice Department.

Generally, the Information systems of Ministry of Health and Vital Registration (under the auspices of Justice Department) seemed to lack the pro-activity and efficiency needed to make use of the routinely collected data to produce an update and useful information for planning purposes. This may reflect the inability of some managers to appreciate the unquestioned relevance of utilising relevant and up-to-date information on which to base definitive development plans, and create visions for future development. It might also be hard for some managers to use the information to indicate what is happening in the organisation without linking it to a reward structure or to use the information to define relevant incentives. It is believed that information and incentive systems are not value neutral, but they can be used to regulate organisational behaviour.

Despite the recognised- importance of an efficient, reliable and updated information system to the development plan of Pacific island countries by Pacific leaders including Tonga, they mainly agree in principle only, but in practice there is little or even none done about it. This may be partly due to the pluralistic perception of priorities in the bureaucracy's management and staff in departments like that of the Health and Justice, and/or partly due to tagged donations from donor- agencies which gives the receiving countries very limited choice for utilisation of donated funds.

Mortality analysis for 1982-1986

The registered deaths from the Vital Registration during this study period was under-enumerated by 31.0% for all Tongans according to the Brass method. This was a considerable percentage of deaths not accounted for. It is very likely that perinatal and infant deaths may be the bulk of those not accounted for. Some contributory factors for that implication could be:

- the lack of appreciation of equal importance of reporting deaths at early infancy and childhood and that of adults,
- the geographical isolation;
- lack of easy means of communicating to the centre,

Table 6. Degree of under-enumeration of registered deaths for Tongans, 1987 - 92

Sources	% of under-enumeration for males	% of under-enumeration for females
Health record	66.7	56.9
Vital Registration	77.3	80.0

** From different sources using the Brass technique (Ref. 23)*

either to the Health sector or the branch of Vital Registration especially in outer islands to report deaths at infancy;

- perinatal deaths are not entered in the mainstream report of Ministry of Health that goes to its information and computing section.

Also, the infant mortality analysis (Finau 1982) did not only provide what was available to the decision makers at the time, but may also support the above high percentage of under-enumeration, especially on early infancy[6]. After a decade from then, Tonga is still waiting for an efficient information system. It is sad to know that some decision-makers do not appreciate the importance of making definitive decisions when updated, correct and useful information are available at their fingertips. But on the other hand, how many of them read and extract useful information from published materials on health and health related journals as most claim that they are too busy to do that. As Loevinsohn[26] has indicated from his study that unless managers accept their limitations to aspects of information management and do something about it, they will continue to feel uncomfortable even with just the most cursory analysis, and that hinders progress. Ignorance is an obstacle to necessary developments and improvements to any society, and that is most damaging when it afflicts the leaders[27].

Table7. Estimates of death rates and expectation of life for Tongans, by age and sex, 1987 - 92

	Females		Males	
Age	Age specific death rate per 1000	Expectation average length of life from age x	Age specific death rate per 1000	Expectation average length of life from age x
Years	(mx)	(ex)	(mx)	(ex)
0	0.0218	72.0	0.0239	68.1
1	0 0011	72.5	0.0014	68 7
5	0.0006	68.8	0 0008	65.1
10	0.0004	64.0	0 0007	60.4
15	0.0007	59.3	0 0014	55.6
20	0.0001	54.3	0.0018	50.9
25	0.0001	49.6	0.0018	46.4
30	0 0002	44 9	0.0021	41.8
35	0 0002	40.2	0.0026	37.2
40	0 0003	35.6	0.0038	32.6
45	0.0042	31.1	0 0059	28.2
50	0.0063	26.7	0 0193	24 0
55	0.0096	22.4	0.0149	20.0
60	0.0153	18.4	0.0232	16.4
65	0 0257	14.7	0.0363	13 1
70	0 0440	11.3	0 0576	10.1
75	0.0749	8.5	0 0917	7.7
80	0.1601	6.2	0 1726	5.6

** Obtained from Mortality life table after adjustment for under-enumeration (Brass technique) and projection onto model life table particularly for correction of infant and childhood mortality.*
Source: Vital Registration, under the auspices of Justice Department, Tonga.

Table 8. Demographic values for Tonga, 1982-86

Population Census 1986	Vital Registration 1982 - 86 mortality data	
Male IMR	26.6/1000 live births	28.3/1000 live births
Female IMR	26.6/1000 live births	23.4/1000 live births
Overall IMR	26.6/1000 live births	25.9/1000 live births
Crude death rate	5.6/1000 Tongan years	5.5/1000 Tongan years
Male life expectancy at birth	67.6 years	66.3 years
Female life expectancy at birth	70.4 years	69.5 years
Overall life expectancy at birth	69.0 years	67.9 years

** From different sources, using United Nations Model life table procedures (Ref. 14)*
**** IMR = Infant Mortality Rate.*

From the demographic analysis based on the 1986 Population Census, an infant mortality rate (IMR) of 20.4/1000 live births was obtained from direct estimate using infant deaths from the year preceding the census, and using the question on date of birth of the last live birth, its survival status and date of death if died. There was an IMR of 25.5/1000 male live births and 15.8/1000 female live births. The IMR for females using the direct estimate seems too low, and also, when compared to the IMR value from the indirect estimate, 26.6/1000 female live births. Part of the reason to obtaining that low value may be lack of stability which is expected in rates dealing with few deaths, as in this case, there was only 19 female deaths in 1985.

Indirect estimate of child mortality for Tongans, based on the 1986 Population Census, was derived using probability of death (q) between birth and exact age x, where x can be 1,2,3,4 ... oo years, using Model Life Table of West Model of Coale and Demeny. This indirect estimate gave an IMR for Tongans of 25.9 years relating to the year 1984.

The estimate of adult mortality from the 1986 Population census used data on survival of mothers at the time of the birth of a respondent and the father at the time of conception, was combined with the estimated child mortality using the COMBIN procedure of the UN MortPak Lite to produce an IMR of 26.6/1000 for both male and female live births. The fact that IMR value for both males and females is very identical, and that raises queries on the reliability of the data, and the accuracy of the method of analysis. However, it was clear from this demographic analysis[16] that the quality of data collected was reliable according to the Child Ever Born Ever Surviving procedure of the Mortpak Lite program[14]. Also, since 1986-92, this document has been the only official demographic analysis of the 1986 Population census printed and available to the public from the Government Department of Statistics. A crude death rate (CDR) of 5.6/1000 Tongan-years was also calculated.

The life expectancies obtained from the 1986 Census were calculated by using the conditional probabilities of adult survivorship by sex from age 20-45 years of age. This was done to avoid the possible adoption effect if younger age groups are used to obtain life expectancies at age 20 years by sex using the West Model mortality. Mortality life tables for Tonga were constructed using the COMBIN program of the UN MortPak Lite, to combine the estimates of child and adult mortality.

Table 9. Estimated infant mortality rate and life expectancy at birth for Tongans, 1982-86

Year	Infant Mortality Rate / 1000 live births (IMR)	Life expectancy at birth (years)
1982	43.0	62.5
1983	39.8	63.4
1984	36.6	63.8
1985	33.4	64.4
1986	30.2	65.1
Average	**36.6**	**63.8**

Source: World Bank Tables. 1993 Edition (Ref. 28)

Table 10. Demographic values, 1987-92*

Indicators	Male	Female	Overall
Infant mortality rate / 1000 live births (IMR)	23.9	21.8	22.9
Life expectancy at birth	68 1 years	72.0 years	70.1 years
Crude death rate (CDR)			5.4

** Obtained from mortality data from Vital Registration.*
Estimated indicator values are from UN Model life table, Mortpak Lite(14)

From the analysis of the 1982-86 mortality data obtained from Vital registration, life tables for Tonga for this period was produced. From these life tables the following demographic values were obtained. life expectancy at birth for males was 66.3 years and for females was 69.5 years; IMR of 28.3/1000 male live-births and 23.4/1000 female live-births, thus a combined IMR of 25.9/1000 live births; and an overall CDR of 5.5 per 1000 population-years (Table 8).

In comparing the demographic values from this aanalysis and those obtained from the 1986 Population Census, the following points are made·

- The life expectancy at birth for males from this analysis was about 1.3 years less than that obtained from the Census. It may not appear very much, but more than a year less for the life of Tongan males may be quite significant when one is expected only to live up to 67 years from birth.
- The females' life expectancy at birth was 0.9 year higher than what was obtained from this analysis, which may be considered close enough;

According to the official document "Demographic analysis of 1986 Population Census of Tonga"[11], the IMR for both females and males were the same, that is 26.6/1000 live births. This provokes queries, especially as it is widely accepted that male deaths are almost always higher than their female counterparts.

As it was argued that the quality of data in the Census was good according to the Child Ever Born Ever Surviving (CBBCS) procedure[14], it could be that values of demographic indicators produced from the Census could be accurate. However on the other hand, the IMR of 28.3/1000 male live births resulted from this treatise analysis was still considered plausible for Tongan males at that time period.

From the World Bank tables, 1993 Edition[28], there were demographic indicator values from 1970-1992. After averaging IMR values from that table for the period 1982-86, an average value for IMR of 36.6/1000 live births, and life expectancy at birth for Tongans of 63.8 years were obtained (Table 9). Though the average IMR value may seem like an over-estimation of the situation as compared to the IMR obtained from the 1986 Population census, and also from the author's analysis of mortality data for the same period, but both, the average IMR of 36.6/1000 Tongan live births and life expectancy at birth of 63.8 years, may not be implausible for Tonga at that period.

Table 11. Estimated Infant mortality rates and life expectancy for Tongans, 1987-92*

Year	Life expectancy at birth (years) (World Bank)	IMR/1000 live births (World Bank)	IMR/1000 live births (Ministry of Health)
1987	65.7	27.0	
1988	66.1	25.8	8.9
1989	66.6	24.6	9.1
1990	67.0	23.4	9.0
1991	67.4	22 2	12.2
1992	67.9	21.0	6.1
Average	**66.8**	**24.0**	**9.1**

** Estimated by World Bank Tables, 1993 Edition (Ref. 28), and IMR from Ministry of Health (Ref. 32).*

Table 12. Estimated infant mortality rates and life expectancies at birth for Tonga from different sources compared to values from this analysis, c. 1990

	IMR/1000 live births (by sex)			Life expectancy at birth (years)		
Source	Male	Female	Overall	Male	Female	Overall
Vital Registration	23.9	21.8	22.9	68.1	72 0	70.1
SPC, UNICEF & UNDP			24.0			69.0
World Bank Tables			26.0			66.8
WHO			9.8			
Ministry of Health			9.1			

Mortality analysis for 1987-1992

The registered deaths obtained from the Health's record for the period 1988-92 was under-enumerated by 38%, while that from the Vital Registration (VIR) was only 21%. Therefore, the data from the VIR which is more complete, was used for the rest of the analysis for this period.

From the 1982-1986 data on deaths registered by the Vital Registration, it was concluded that the degree of completeness of death registration needs to be improved. This appears to be the case as in 1987-92 male death registration was improved by 10.0 percentage points and females by 9.0 percentage points, compared with the previous period. It was likely that Health Department and Vital Registration, under the auspices of Justice Department has started to work together. Through oral communication with the Medical Superintendent during the research for this study, he said that since 1989 he had informed all medical doctors that all deaths, either in hospital or outside of hospital must be issued a death certificate from the Department, and later validated with the Vital Registration.

As seen earlier on the mortality data collected by the Ministry of Health, its registered deaths was worse in its completeness than that collected by the Vital Registration.

It seemed that registration of male deaths was slightly better than the females'. However, it may be argued that improvement of death registration from the first period analysed (1982-86) to this period (1987-92) for both male and female deaths was about the same. It is of interest that the male female death ratio over the duration of the study period remains fairly constant at an average of 1.3.

For the period of 1987-92, and from the Mortality life table, using the UN Model life table using General pattern from the Mortpak-Lite, the adjusted IMR was 23.9/1000 male live-births and 21.8/1000 female live-births, thus giving a combined IMR of 22.9/1000 live births (Table 10). Considering that the IMR for males is always higher than that of females, the male:female ratio of about 1.1 for IMR may be reasonable. An adjusted life expectancy at birth for males was 68.1 years, and for females was 72.0 years, thus giving a combined life expectancy at birth of 70.1 years. The adjusted CDR was 5.4 per 1000 population-years.

Demographic values for the same period of time from other sources were examined. These included the tables presented from UNICEF and UNDP by Bryant-Tokalau, 1994[15], a table presented by WHO in the article by Lewis et al, 1994[16], World Bank Table 1993 edition[28], SPC Statistical Bulletin, no.42, 1994[29] and State of Pacific children (SPC)[30]; and UNICEF, 1991[31] SPC, and UNICEF and UNDP presented an average IMR of 26/1000 live births and an average life expectancy at birth of 66.8 years for Tonga for the period around 1990. They might have used the same data source, probably the 1986 Population Census.

The demographic values obtained from the World Bank Table 1993 Edition[28] for the period of 1987-92 were averaged and obtained an average IMR of 24/1000 live births and an average life expectancy at birth of 66.8 years. However, from Annual Report of Minister of Health[32] for the same period, it gave an averaged IMR of 9.1/1000 live births (Table 11).

Therefore, the average IMR from other sources in comparison to the demographic values obtained from this study's mortality analysis were comparable except the IMR of 9.8/1000 live births for 1990[16] and 9.1/1000 live births from Ministry of Health[32] (Table 12). It is very likely then that WHO received that IMR information from the Ministry of Health who might have calculated an unadjusted IMR based on mortality data collected by the Health Information and Computing section (HICS) of the Ministry.

As seen earlier on the mortality data collected by the Ministry of Health, its registered deaths was worse in its completeness than that collected by the Vital Registration. All health and health related information is prepared and produced annually by HICS and presented as the Health

Minister's Annual Health Report. The same applies to the Statistic Department of the Justice Department.

Also putting IMR of 9.8/1000 live births for Tonga against the United Nation Model life tables, using the United Nations general pattern of Mortpak Lite COMPAR program, an average life expectancy at birth for males of 76 years and for females of over 80 years was implied. This level of life expectancy at birth for males and females and an IMR of 9.8/1000 live births seem implausible for Tonga today. They are more the characteristic of developed countries, such as United States, Japan and United Kingdom. The fact that IMR produced by the Ministry of Health is too low for plausibility may be an indication that management of its information system needs assistance.

Life expectancies from SPC, UNICEF and UNDP were quite comparable with the values obtained from this analysis, even though they are 0.9 years less, which may be considered acceptable. However, the life expectancy from birth obtained from the World Bank Tables was 3.3 years lesser than that obtained from this analysis. It is considered that over 3 years less in the life of a Tongan is almost like a life-sentence for them. Comparing the above demographic values with the rest of the Pacific, Tonga fares much better than most of the Pacific nations except a few of the territorial countries, like New Caledonia, Cook Island and Niue[10, 15,16,19,20,28-33].

Conclusion

The analysis of the intercensal mortality data for Tonga, 1982-92, from the Vital Registration has produced plausible and useful demographic information as compared to various other sources. That leaves us with the question of how would the information systems, especially that of Health Department and Vital Registration, under the auspices of Justice Department, be made to be pro-active, efficient and collaborative with each other. Tonga needs people who are research orientated to make use of the vast supply of routinely collected data to provide useful and timely information for the decision-makers. Thus there is need to train personnel with the appropriate skill, which is not just to use data to set out tables and figures, but to be able to interpret them into useful information for development planning purposes.

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... the knowledge of epidemiology is an essential tool to possess by health workers at all levels. It will not only lead to improvement of performance but also to better appreciation of services performed and better job satisfaction.

Dr. Supileo Foliaki 1985, in Studies from Epidemiology Training Workshop in Tonga