CONCEPTS AND MEASURES OF SELF-HARM AND SUICIDE: LOCATION AND DISTRIBUTION OF POTENTIAL YEARS OF LIFE LOST FOR AUSTRALIA, 1907-2003

By

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ABSTRACT

Rising suicide rates have been identified as a social problem in a number of Western countries. One purpose of this paper is to employ an alternative measure of suicide, potential years of life lost, rather than a count of the number of suicides, or a rate based on a count. This measure provides several useful dimensions for quantitative analysis. The paper begins by placing suicide in a wider perspective of self-harm. We then demonstrate that, despite the (almost) universal use of the suicide rate (number of suicides per 100,000 people), whether that rate be crude or age-adjusted, the measure of potential years of life lost enables, not only characteristics of location (such as the mean) to be calculated, but also various characteristics of dispersion (the standard deviation, the coefficient of variation, the Gini coefficient etc) to be determined. Dispersion measurement of health phenomena was pioneered in the 1980s by Jacques Silber and Julian Le Grand, in a literature that is now described as measuring *pure health inequality* or health inequality *per se.* Finally, the empirical part of the paper illustrates these general considerations with Australian data for the period 1907-2003. In that part of the paper attention is drawn particularly to measures of the statistical distribution of age at death by suicide.

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"The desire for the prolongation… of life we may take to be one of the most universal of all human motives" [1].

1. INTRODUCTION

Given that suicide is an increasing cause of death in the developed world, as demonstrated by La Vechia, Lucchini and Levi, [2], various Western countries (e.g. the US, the UK, and Australia) have recently identified suicide as a public issue and have stated policies, and adopted strategies, to reduce it.[1] However changes in the occurrence of suicide are not uniform by age-group: suicide rates have declined for the elderly and risen sharply for the young. The authors of a recent paper have written as follows: "Suicide is now the second or third leading cause of death for youth in the US, Canada, Australia, New Zealand, and many countries of Western Europe" [10]. In the State of Queensland suicide is now the highest cause of death in the 10-14 year age group [11].

A relevant subject of economic investigation is the quantity, or level, of mortality in a population. The stock of health in a population yields a flow of services, as indicated by Grossman [12] [13] [14]. Thus the flow ceases at mortality. However, relatively few economists study the distribution of health, i.e. health *per se*. Silber [15] [16] [17] and Le Grand [18] [19] [20] applied conventional economic measures of inequality to data on age-at-death and show that Lorenz curves can be derived from such data. Gini coefficients, standard deviations and so forth can also be applied to mortality data using procedures that are analogous to the study of income distribution. In addition, Hicks and Stretton [21] have also argued that mortality measures are appropriate for measuring human welfare progress.

This study answers four research questions. First, has suicide activity among males and females increased, decreased or remained constant through time in Australia? Second, is the conventional method for measuring suicide, based on the age-standardised suicide rate, i.e. the number of suicides per 100,000 population, telling "the story" about suicide adequately? Third, has the age distribution of suicide for males, and for females, increased, decreased or remained constant through time in Australia? Fourth, is there any evidence of structural changes in the Australian experience of suicide through time, which is suggestive of further research?

Some may question why we should be concerned with suicide: it can be argued that this is a supreme act of free will, often in the context of incurable illness. Although this may be the case for some, there is a long-standing literature which documents a link between mental health status and

[1] In the UK, a reduction of the suicide rate was one of a number of health targets stated in *The Health of the Nation* [3]. For subsequent developments see Department of Health [4] [5]. Following the description of suicide as a serious public health problem by two 1997 resolutions of the US Congress, the US Public Health Service [6] published *The Surgeon General's Call to Action to Prevent Suicide*, and then the National Strategy for Suicide Prevention was outlined in 2001 (www.surgeongeneral.gov) . Suicide was first identified by the Australian Government as an issue when its prevention was identified as a national target in *Better Health Outcomes for Australians*… [7]. Subsequently a youth suicide prevention strategy was developed in 1995, and then in 1999 the National Suicide Prevention Strategy was adopted [8] [9].

suicide, attempted or completed. Many of the people who take their own lives have a prior history of mental illness, often associated with co-morbid substance abuse of alcohol and/or drugs. The more recent of these studies have employed the technique of psychological autopsy, *i.e.* a post mortem study of consecutive suicide deaths in a specific region or country, details being obtained from relevant informants (family members and significant others) [22]. This connection between mental illness and suicide has been documented for both the young [23] and the elderly [24]. An example of these results is the psychological autopsy results for Finland by Henriksson, Aro, Marttunen *et al.* who applied DSM-III-R diagnoses to suicides in the 12-month period to 31 March 1988 [25]. Some of their conclusions were as follows: "One or more diagnoses of mental illness on axis I was made for 93% of the victims. The most prevalent disorders were depressive disorders (59%) and alcohol dependence or abuse (43%)" (p.935).

This paper is organised as follows. Section 2 is concerned with placing suicide in a wider perspective of public policy and welfare economics. Section 3 is concerned with various issues of perspective and measurement which are relevant to suicide. Section 4 presents some empirical results and the final section provides a discussion of the significance of the empirical results.

2. SUICIDE IN THE PERSPECTIVE OF PUBLIC POLICY AND WELFARE ECONOMICS

Governments, by their statements, seem to take the view that suicide is "a bad thing". So there is an inverse relationship between community welfare and suicide. Furthermore, politicians/ bureaucrats say that it is a greater tragedy when young people take their own lives. Thus, social welfare falls when the young (rather than the old) take their own lives.

One way of describing these two points is to say that the (partial) social welfare function (W_1) has two arguments, *viz.* the total social loss from suicide, and the distribution of age-at-death from suicide. Thus,

$$W_1 = f(SLfS,\ I_s/E_s) \tag{1}$$

where $SLfS$ is the social loss from suicide, and I_s/E_s is the notation for "inequality/equality" in the distribution of age-at-death from suicide.

Before proceeding to issues of measurement of these two variables in (1) it is relevant to place these concerns in the wider framework of welfare economics.

A conventional approach in welfare economics is to specify social welfare (W) as a function of the utility levels of the n individuals who comprise the community. Thus we may write:

$$W = f(U_1, U_2, ..., U_n) \tag{2}$$

where U_i is the utility level of person i. See Nath [26] for an elaboration of the value judgements associated with equation (2).

Dissatisfaction with such a social welfare function arose during the debate on welfare criteria initiated by Kaldor [27], and was quickly followed by contributions from Hicks [28] and Scitovsky

[29]. This "tortuous debate", to use Mishan's [30] phrase, culminated in what is now known as Little's criterion [31]. Little's argument essentially is that the attempt to separate production and distribution (as had been the objective of the earlier contributions) was futile.

Thus, following Little, we may write

$$W = f(U_1, U_2, ..., U_n;\ I_U / E_U) \qquad (3)$$

where equation (2) is augmented by I_U / E_U , some measure of the distribution of welfare between the members of the community.

These distributional matters received some considerable attention in the literature on social investment appraisal, where a number of different empirical approaches were developed to incorporate distribution in cost-benefit analyses.

The Little criterion involves the provision of efficiency information and distributional information to decision-makers. Marglin [32] then suggested that planners/economists should aim to present information to decision-makers which maximises "a weighted sum of redistribution and efficiency". Weisbrod (1968) [33] devised a way of implementing Marglin's suggestion by inferring distributional weights from previous governmental decisions: his procedure involves the simultaneous solution to a system of equations. Neenan [34] applied this technique in his analysis of an X-ray screening programme to detect tuberculosis.

Another approach to integrating efficiency and equity, first suggested by Eckstein [35], is to infer distributional weights from a situation in which redistributional issues are at the forefront of attention: the personal income tax legislation (in western countries) is such a case. Mera [36] devised a procedure to do this and Nwaneri [37] applied the approach in re-working the Roskill analysis of the (then proposed) Third London Airport. Using Australian income tax schedule Doessel [38] applied this technique in his cost-benefit study of four alternative measures of treating end-stage renal disease.

It is now not atypical to see welfare functions such as that indicated in equation (3) in the theoretical literature. Graaf's argument is that there is a need to "dispense with the time-honoured device of drawing a distinction between the size and the distribution of national income and saying that welfare **depends on them both**" [39]. This statement is reminiscent of Little's critique of Kaldor: "[Kaldor] suggested not a test, but a definition, which certainly separated out income distribution, but only by ignoring it… We do not believe that any definition of an increase in wealth, welfare, efficiency, or real social income which excludes income distribution is acceptable" [31]. See also Fisher [40], Sheshinski [41], and Fields [42]. More recently Sen [43] has re-argued the case for incorporating distribution in (generally) standard-of-living comparisons. He argues that the welfare theory of real national income comparisons is deficient particularly with respect to income distribution. His procedure is to weight goods to different people by distributional judgements. Thus, a concern for I_U / E_U in the welfare function now has many precedents.

As yet we have not specified the content of the utility function, U_i. It is conventional to say that the arguments in U_i are goods/services consumed. Thus

$$U_i = f(X_i, Y_i) \tag{4}$$

where X_i is the amount good *x* consumed by person i, and Y_i is the amount of good *y* consumed by person i, and given that,

$X = \sum X_i$ and

$Y = \sum Y_i$,

then equation (3) can be re-written as

$$W = f(X, Y; I_U / E_U) \tag{3a}$$

Note that equations (3) and (3a) are timeless.

Although the importance of time has been recognised in economics in the context of investment appraisal since Fisher [44] it was not until 1965, with the publication of "A Theory of the Allocation of Time" by Becker [45], that time was incorporated into the body of microeconomics. One of Becker's key points was that the consumption of goods actually **takes time**: this is clearly recognised in the context of going to the theatre for a musical concert, a play or a film, having a restaurant meal etc: recognition of the jointness of consumption of goods and time leads quickly to the concept of a time-price associated with the money-price of the consumption of a good. In the health sector this has led to the calculation of time-prices associated with the consumption of health care services, the first study being that of Acton [46].

It is relevant to observe that this jointness between the consumption of goods and time is not simply restricted to particular consumption goods, but is applicable to all consumption. If we consider the conventional utility function in equation (4), it is clear that this function takes no account of the jointness discussed above. One way to recognise this is to re-write equation (4) as follows:

$$U_i = f(X_i, Y_i; t_x, t_y) \tag{5}$$

where t_x and t_y are the times associated with the consumption of X_i and Y_i. It is important to note that this equation is exactly the same as Becker's equation (4), with the exception of notation [45].

It is recognised in equation (5) that time (associated with consumption) is an argument in the utility function for person *i.* Summing across *n* persons, we have total time (T) as follows:

$$T = \sum_{i=1}^{n} t_x, t_y$$

Given that time enters the utility function, there is but a small step to recognise that time also enters the social welfare function (*W*). Thus we may re-write equation (3a) as follows:

$$W = f(X, Y; I_U / E_U; T) \tag{3b}$$

We assume that W is increasing in X and Y: given that T is jointly involved with X and Y, it follows that W is also increasing in T. Thus the times of consumption (or part lives) of the members of the community is an argument in the social welfare function.

Death from any cause (including suicide), will decrease the value of the social welfare function. Given that inequality/ equality (associated with goods) is an argument in the welfare function, and that people jointly combine goods and time, it follows that the distribution of time is also a component of W. Thus we may write:

$$W = f(X, Y;\ I_U / E_U\ ;\ T;\ I_T / E_T) \qquad (3c)$$

Let us now return to equation (1), a statement of government concern for social loss from suicide and its distribution. This equation was described as a partial social welfare function. Given that time (and its distribution), have now been shown, equation (3c), to be arguments in the general social welfare function, the statement of W_1 in equation (1), can be seen as a part of W in equation (3c). In other words, a concern for suicide (and its distribution) can be regarded as part of the general body of welfare economics.

Thus extensions of modern welfare economics writing provide a justification for time to enter the social welfare function. It is relevant to note that this conception may not be accepted by all people: some may admire the suicide of honour, epitomised by the acts of Seneca, Lucretia, Brutus and Portia, and Mark Anthony. For others, suicide is an act of personal autonomy, free will or self-determination and people in the West are often puzzled by *sati (or suttee),* the Indian funeral custom in which a widow immolates herself alive on her husband's funeral pyre. Also it is clear that the concept of the absurd in existentialist thought leads to suicide being regarded as quite understandable: as there is no purpose, value on meaning in the world or to life, suicide is an obvious response.[2] Indeed, for Camus [48], suicide was the "one truly serious philosophical problem", and his answer was to struggle and revolt against the absurd [49]. Rebellion, for Camus, implies dissatisfaction with the human condition, i.e. one needs to face the absurd, and make a decision in favour of life. See Lengers [50] for a discussion of Camus' perspective for the role of health professionals.

Attention is now directed to some issues of measurement.

3. MEASURING THE EFFECT OF SUICIDE

This section is concerned with issues of perspective and measurement. Although the emphasis is on measurement of the societal burden of suicide, and two ways of measuring it, it is useful to begin by placing suicide in the wider perspective of self-harm.

3.1 Self-harm and Suicide

It is relevant to begin by pointing out that suicide is but a part of the wider phenomenon of "intentional self-harm": another sub-set is that of parasuicide (or "attempted suicide", or "intentional self-inflicted

[2] It is useful to observe that this conception has some similarities with the analysis in Hamermesh and Soss [47]

injury"). This later sub-set can be disaggregated into acts of intentional self-harm that involve hospitalisation and those that are not hospitalised. Although it is recognised that recorded suicides are an underestimate of all suicides[3], some data (available from the authors, on request) are available.

These distinctions are important, given that there are major demographic differences between suicide and parasuicide. See also Cutler, Glasser and Norberg [10] for an empirical analysis of those differences in the US.

3.2 Measures of the Societal Loss from Suicide

We begin by addressing a number of prefatory points surrounding measurement in general. Given that various governments have identified "the problem of suicide" as a policy issue, there remains the problem of measurement: how is "the problem of suicide", or "the social loss from suicide", to be measured? One way to comprehend this matter is to consider the econometric literature on measurement error, stemming from Goldberger and Joreskog [54] [55] [56], i.e. the latent variable approach. This recognises that there is no exact measure of the theoretically appropriate concept (in this case, the $SLfS$), and that the various proxy measures, such as the number of suicides, will measure the concept with error. This problem (when a relevant variable cannot be directly observed or measured) is common place in empirical economics: an example is Friedman's notion of "permanent income", an unobservable, whereas current income can be observed and measured and can be an **indicator** of permanent income.

At present we are interested in recognising that there are various imperfect measures that shed some light on the $SLfS$, and that measurement may be determined by context or perspective. Take the case of a parent with two children who take their own lives. One of the children is 35 and the other is 15. A parent may take the view that each suicide involves the same loss, irrespective of age. However the parent may view these suicides from a personal perspective, i.e. it is a "personal trouble", whereas a social perspective leads to the view that the two cases do not involve the same loss: a "public issue" perspective may weigh the death of the younger person more highly than the older person, to use Mills' terms [57].

A third point is that there are two perspectives from which change in human affairs can be viewed, or measured. The first is "attainment", *i.e.* measuring what has been achieved, in which a higher value in a relevant index indicates an improvement. The second approach is one of relative "deprivation" or a shortfall: this perspective involves the specification of a desired value, a target, or an objective for a particular index. Runciman [58] provides a concise definition of relative deprivation. A decrease in the difference between an actual value and the desired value of a particular measure indicates an improvement. An important example of a (relatively) new deprivation index is

[3] It is well known that official statistics on suicide involve underestimation. For some details see Australian Bureau of Statistics [51], and DeLeo and Evans [52], and more generally Rocket and Thomas [53].

the Human Development Index, first calculated in 1990 (United Nations Development Programme, 1990, Technical Note 3) (p.109) [59].

The perspectives of "attainment" and "deprivation" can also be seen in the field of demography, more particularly in the context of the life table. The particular concept of interest is the survival curve which depicts the temporal mortality experience of a cohort born in a particular year. This curve splits the space into two regions, *viz.* years of life lived, and years of life lost due to premature mortality. It is well known that survival curves shift through time, given various factors such as improved nutrition, medical/surgical interventions etc. Such factors led Fries [60] to speak of "the rectangularisation of the survival curve" for high-income countries.

Figure 1 indicates a survival curve for a particular population (a cohort of 100,000 born in year 1) with an arbitrary cut-off at 100 years. The area below the survival curve measures the years of life lived by the hypothetical cohort, and the area above the curve indicates the potential years of life lost (PYLLs) by the cohort, a concept first defined by Dempsey (1947) [61]. However Dempsey did not take 100 as the limit of life: rather she arbitrarily chose life expectancy at birth. Let us assume that this is 75 years. See BD in Figure 1.

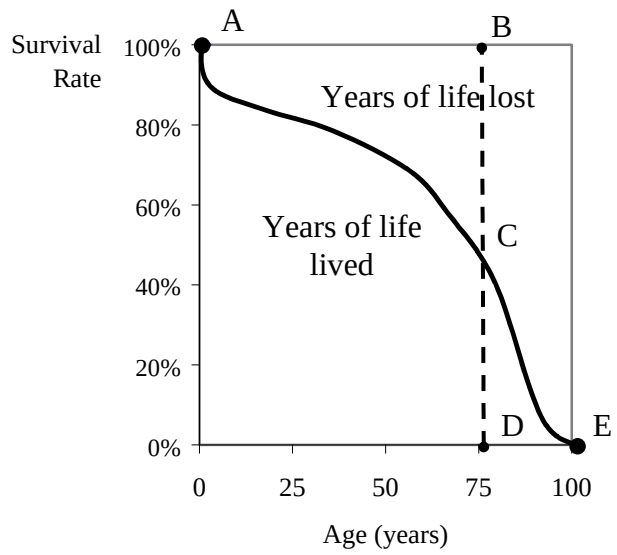

Figure 1. Survival curve measuring the life years in a hypothetical cohort of 100,000 population born in year *i*

It is useful to ask ourselves the following question: what is the significance of the area under the curve (to age 75) and the area above the curve (to age 75)? Put otherwise, what is involved with a survival curve that has the following shape: ABCDE (rather than ACE)? The area to the left of BD would indicate the total years of life lived, given that the PYLL were zero. This case is one in which premature mortality (to age 75) has been eradicated, which is an extreme case of rectangularisation (to age 75).

Now the papers of Silber [15] [16] [17] and Le Grand [18] [19] [20], the first scholars to study the distribution of health *per se*, were concerned with analysing the years of life lived before death, or more simply the distribution of age-at-death (the area below the survival curve in Fig. 1). Another way of putting this is that they were concerned with attainment, as outlined in, say, the *Human Development Report* [59]. But the PYLL (the area above the survival curve) measure can be appropriately conceived of as a "deprivation" measure, and can be equally well analysed in terms of its distribution (by calculating Ginis, and other measures of dispersion.)

It is relevant to observe that Lorenz curves (and associated measures such as Gini Coefficients etc) can be calculated on **both** the attainment (years of life lived) and the deprivation (potential years of life lost) measures that are associated with the survival curve. However, it is important to recognise that, because of the complementary relationship between these two concepts that such measures (the Lorenz Curve and the Gini Coefficients) are "normal" for the attainment measure, but are "inverse" for the deprivation measure. More specifically, the Lorenz Curve for the PYLL measure has the **form** of what is now commonly called "the concentration curve", following the (now extensive) work of Wagstaff, van Doorslaer and Paci [62].

Dempsey (1947, p.157) [61] argues that measuring death by a count of the number of deaths (or any measure based on it, e.g. the death rate) "fails to tell the whole story". Such a measure implicitly places an equal weight on each death. If one is concerned with "the relative importance of diseases" on "the seriousness of a disease" (p.1158), then this measure is not appropriate: A more appropriate measure is the "potential years of life lost". The example given relates to the death of a white woman at the age of 24 or 62. Given that life expectancy of members of this group (in the 1940s) was 69 years, in the former case death involved a loss of 45 years whereas the latter involved only a loss of seven years.

Measuring the effect of suicide (or any cause of death) by a simple count of deaths and any measure based on it, e.g. the suicide rate, places an implicit, and equal, weight on suicide: a suicide is a suicide. In some circumstances this measure may be appropriate as argued previously in terms of a "personal trouble", but in other contexts it "fails to tell the whole story" (p.157). In a social context, such as the scale, the relative significance of various diseases or health problems, this focus may not be appropriate.

There is a (virtually) universal practice of using a count of the number of suicides (and other measures based on such counts, e.g. the number of suicides per 100,000 people) to measure what is referred to here as the *SLfS* .[4] An alternative way to proceed is to use a different **measure** of the social

[4] To our knowledge there is only one brief paper (a letter) which has previously applied to the PYLL measure to suicide [63]. There is no prior Australian study which has applied the PYLL measure. This is not to imply that there are no Australian studies on suicide: there is a large number of studies that focus on one descriptive dimension or other. For example there are studies on youth suicide [64] [65], geographical differences [66] [67], as well as more general studies [68] [52]. However the point is that none of these studies employ the potential years of life lost measure of suicide.

loss from suicide, a measure which gives recognition to the value judgement that a "young" suicide is more tragic than an "old" suicide. Such a measure is the PYLL, a demographic measure of time or life (measured in years) lost due to premature death, first advocated by Dempsey in 1947 [61]. The calculation is relatively straightforward: choose an arbitrary potential limit to life, and life lost from premature death is the difference between that limit and age-at-death. Dempsey's example was to consider the death of a white woman at age 24, and at age 62, given that life expectancy was 69 years. In the first case there would be 45 years of life lost whereas there would be only seven years lost in the second case. Although Dempsey [61] argued that the limit to life should be defined by life expectancy at birth, there is no unanimity on this issue in the literature. The Australian Bureau of Statistics [69] uses the median age-at-death (for persons), currently (in 2005) 79 years. The PYLL measure has been given some prominence in recent years as a result of it being a component of the burden of disease concept associated with Murray and Lopez [70]. However it should be noted that the Murray and Lopez calculations do not employ the PYLL concept, but rather a related concept (the standard expected years of life lost), as well as provision for discounting and age-weighting. For details see Murray [71].

The point is that a simple count of the number of deaths (and any measure based on it, such as a rate) has an implicit and equal weight on deaths: a suicide is a suicide. As argued previously, this may be an appropriate measure, but in other contexts as Dempsey says, it "fails to tell the whole story" [61]. For Dempsey, it is not appropriate if one is concerned with "the relative importance of diseases", or "the seriousness of a disease" (p.158).

At this point it is important to recall the earlier discussion of latent variables: any death, including suicide, is multi-dimensional and has different meaning or significance to different people. Thus, as pointed out previously, the PYLL measure is also an imperfect measure of death.

4. EMPIRICAL RESULTS

4.1 The Data

A particular advantage of measuring $SLfS$ by PYLLs is that an analysis can be undertaken, not only of the quantity of mortality, but also its distribution by age. This Section describes how the necessary data sets for answering the research questions were calculated.

Annual data on mortality due to suicide in Australia are available by five-year age groups from 1907 till 2003, providing 97 annual observations [72]. The age at suicide is recorded by the Australian Bureau of Statistics (ABS) in one of eighteen age groups, with the uppermost category being 85+ years. The suicide PYLL generated for this study thus involves data about the entire population: not a sample. The details of the calculations undertaken for this study are available from the authors on request. Briefly, we report here only age-standardised results and calculations based on 75 years as the potential length of life. This explains the notation $PYLL(75)_{AS(S)}$ employed below.

The data on PYLL(75)$_{AS(S)}$ per 100,000 population from 1907 to 2003, for males and females, are presented in Fig 2, as well as the age-standardised suicide rate per 100,000 population, i.e. the MR$_{AS(S)}$, for Australia. Several observations can be made from this Figure. First, there is a gender difference. The well-documented gender difference in mortality due to suicide [52] is visible also in the male and female PYLL(75)$_{AS(S)}$ rates. Second, Figure 1 enables one to contrast the two measures of suicide. The use of two scales and both Y-axes, representing the two measures of suicide, enables comparisons between the suicide trends provided by these measures: the different measures tell different "stories". The disparity in the stories is more noticeable in male suicide than in female suicide. For example, there was a high male suicide rate during the first 30 years of last century but the PYLL(75)$_{AS(S)}$ rate is low. Suicide at that time occurred largely in older age groups. The trend in the post-war years indicated by suicide rate is different also from that indicated by PYLL rates. Third, the Figure is useful because we observe the PYLL data visually. Doing so suggests the approach to the statistical modelling to determine whether the quantity of suicide in Australia has risen, fallen or remained constant through time.

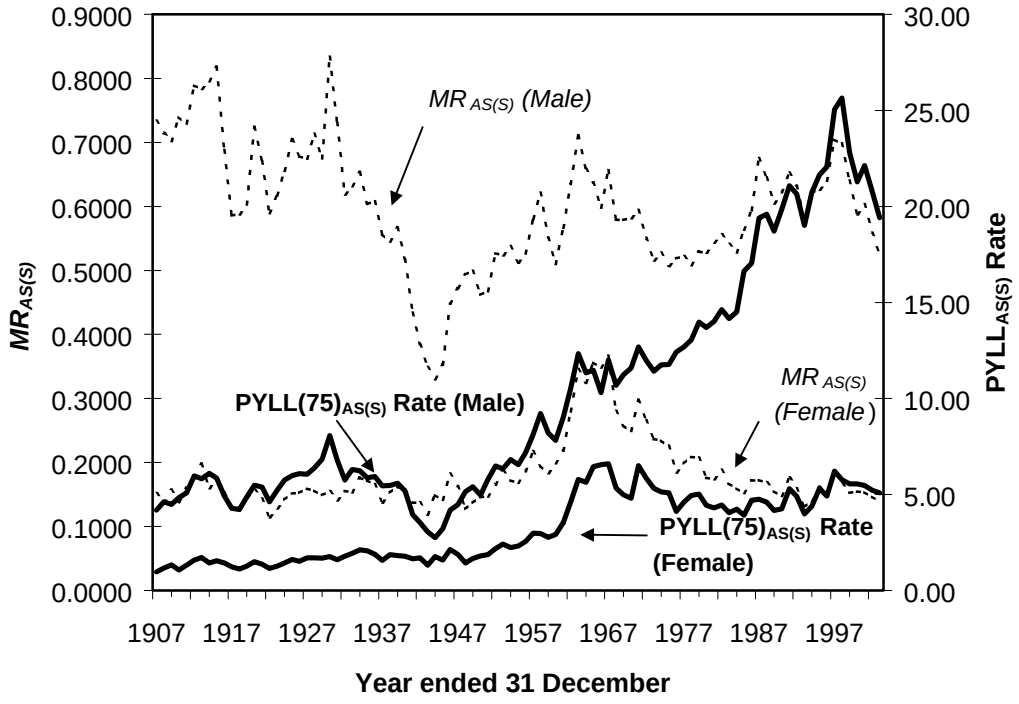

Figure 2. Suicide. Age standardised potential years of life lost per 100,000 population and age standardised rate of mortality per 100,000 population: Males and females, Australia, 1907-2003

Source: Data from [69]
Note: MR$_{AS(S)}$ is the mortality rate, age standardised, for suicide per 100,000 population, per year. The PYLL(75) $_{AS(S)}$ Rate is the age standardised total number of potential years of life lost [PYLL(75)] to suicide per 100,000 population, per year.

4.2 Generated data on age distribution

In this study, we generated two additional time series data sets for measuring the age distribution of suicide: the coefficient of variation (COV) on the PYLL(75) $_{AS(S)}$; and the Gini coefficient on the PYLL(75)$_{AS(S)}$, both for males and females. These data sets answer the research question: has the age distribution of suicide widened, narrowed, or stayed constant?

Figures 3 and 4 show the COVs and Gini Coefficients for male and female PYLL(75)$_{AS(S)}$ for Australia from 1907 to 2003, respectively. Note that the trends in these two figures appear to be quite different between the genders and also between the measures. This is to be expected. The formulae for the COV and the Gini are quite different. Also, it is well established in the literature on income inequality measurement [73] that each of the various measures of a distribution are summary measures involving different implicit assumptions about a distribution.

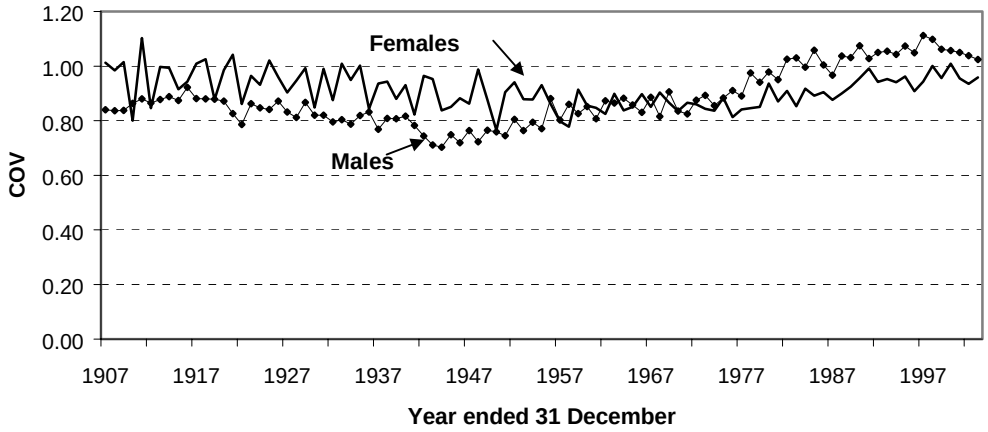

Figure 3. Suicide coefficients of variation. Age standardised potential years of life lost, PYLL(75)$_{AS(S)}$: Males and females, Australia, 1907-2003

Source: Data from [69]
Note: See Figure 2.

4.3 Interpreting PYLL-based suicide measures

Broadly speaking, a declining PYLL rate indicates relatively fewer suicides are occurring among younger age groups. A rising PYLL rate indicates relatively more youth suicide. Consider the interpretation of Gini coefficients on PYLL distributions. Recall that on an income distribution, a Gini coefficient of unity indicates perfect inequality in a distribution, while a Gini of zero indicates a perfectly equal distribution. A very high Gini coefficient indicates the PYLL are unevenly spread across all age groups, whereas, very low, or zero, Gini coefficient on suicide PYLL data indicates the PYLL are evenly spread across all age groups.

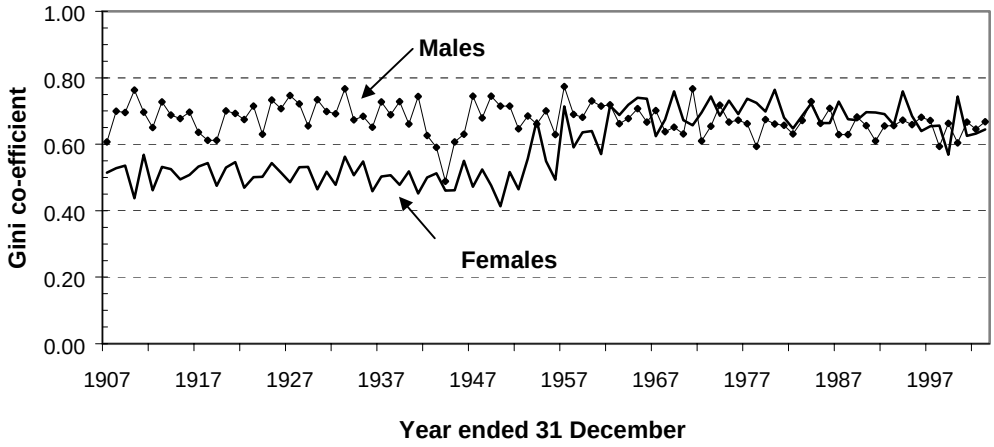

Figure 4. Suicide Gini coefficients. Age standardised potential years of life lost, $PYLL(75)_{AS(S)}$: Males and females, Australia, 1907-2003

Source: Data from [69]
Note: See Figure 2.

Table 1 summarises these broad interpretations. One must approach the interpretation of trends in PYLL rates and distributions with caution. It is more difficult to interpret movements in the PYLL rate and Gini coefficients when they take values in between the extreme values, as Table 4 in the Discussion suggests. Reductions in PYLLs in some age groups will, for example, usually unequally balance increases in PYLLs in other age groups. It is therefore important to examine PYLL-based measures alongside mortality rates. Both measures are relevant. (This point is an analogue of the argument in equation (3a) that the quantity of X and Y are relevant to social welfare as well as the distributions of those variables. It is also important to realise that value judgements are implicit in all such measures, a matter to which attention turns in the Discussion section.

TABLE 1: INTERPRETATION OF PYLL-BASED SUICIDE MEASURES

$PYLL_{Rate}$	Interpretation [i.]	$Gini_{PYLL}$	Interpretation [i.]
Falling	There are fewer suicide in younger age groups	Unity or near zero (Absolute inequality in PYLL age distn)	$PYLL_{suicide}$ is concentrated in a few, or one, age group/s
Rising	Suicide at relatively young ages is increasing	Zero or near zero (Absolute equality in PYLL age distn)	$PYLL_{suicide}$ is spread evenly across all age groups

Note: i. See Discussion section and also Table 5 for welfare implications.

4.4 Statistical Analysis

The research questions are answered by estimating time-series models, using E-Views [74] on the six generated time series data sets (i.e. the three measures of suicide, described above, for males and females), a total of six equations. By way of comparison, two additional equations were estimated, on the $MR_{AS(S)}$ for suicide, males and females for the same time period.

Let us turn attention first to the model of the trends through time in Australian suicide, male and female, as measured by the $PYLL(75)_{AS(S)}$ rate per 100,000 population, depicted in Figure 2. Casual observation of the data suggests some non-linearity, and general-to-specific methodology suggests beginning with, say, a fifth order polynomial. The approach to finding the equation of best fit is the application of conventional Goodness-of-Fit tests and also a battery of diagnostic tests. Equation (6) presents a general polynomial form, i.e. to the *k*th power:

$$SM/F_t = \alpha_0 + \alpha_1^t + \alpha_t t^2 + ... + \alpha_k t^k + \alpha_l X_l + \mu_t \quad (6)$$

where SM/F_t is the quantity of suicide [the $PYLL(75)_{AS(S)}$ rate, and the $MR_{AS(S)}$] for males/females at time period *t*; X_l is a vector of historical variables that may affect SM/F_t; μ_t is a "well-behaved" error term; and $\alpha_0, \alpha_1, ..., \alpha_l$ are parameters to be estimated.

Also, different eras in suicide activity through time are apparent in the data presented in Figure 2, suggesting that the incorporation of dummy variables may be relevant.

A general functional form is given in equation 7 for modelling of equations concerning trends in the age distribution of age-at-suicide through time, as measured by the COV and the Gini coefficient:

$$S\ I/E\ M/F_t = \beta_0 + \beta_1 t + \beta_2 t^2 + ... + \beta_k t^k + \beta_l X_l + \gamma_t \quad (7)$$

where $S\ I/E\ M/F_t$ is suicide inequality (the COV or the Gini) for males/females at time period *t*; X_l is a vector of historical variables that may affect $S\ I/E\ M/F_t$; γ_t is white noise (and another "well-behaved" error term); and $\beta_0, \beta_1, ..., \beta_l$ are parameters to be estimated.

The purpose of the statistical modelling is to provide some confidence that the coefficients of the "best fit" equation for each measure are not spurious, and to provide the magnitude of, and extent to which, the measure of suicide and its age distribution has risen, fallen or remained constant through time, in terms of the measures of suicide applied here. However, the task is more than a curve-fitting exercise here, as variation in suicide activity through time is apparent, and the statistical analysis enables the detection of different periods in suicide activity.

4.5 Results

The results for the equations fitted to the $PYLL(75)_{AS(S)}$ rate (males and females) and the $MR_{AS(S)}$ (male and female) are presented in Table 2. Note there are several dummy variables, i.e. DV1930-31 is a dummy variable that takes the value of unity from 1930-1931, and so forth. The "best fit" equation

on the male PYLL data involves a rising quadratic with three dummy variables and one autoregressive error term (ARI) to address the serial correlation. The recent decline in suicide activity proved insufficient in magnitude for a cubic form to pass the Ramsey RESET test. The estimated equation for male $MR_{AS(S)}$ for suicide in Table 2 indicates that the equations are different. Note that, while a cubic equation fits well on the Ramsey RESET test, the statistical significance of the coefficients is not high. Only two of the three dummy variables in the PYLL equation are in the $MR_{AS(S)}$ equation. Clearly, the equations on PYLL and the suicide rate tell different stories about suicide activity.

The best fit equation for female PYLLs incorporates a single dummy variable, DV1962-2003 but, otherwise, it is linear (with an AR1 term). The statistically significant coefficient on the dummy variable suggests 1962 began another era of female suicide. When an equation is fitted to the female data on the suicide rate, the best fit equation is very different from that on the PYLL data. The functional form is cubic, and the dummy variable is applicable to a narrower span of years (1962-75) than that in the PYLL equation. The implication is that, once more, the PYLL measure and the mortality rates tell different stories about suicide activity.

Let us now turn the focus to the equations estimated on dispersion measures. Table 3 presents the results for the equations fitted to the COVs (males and females), and the Gini coefficients, on the distribution of PYLL-based measures of age-at suicide. "Saucer-shaped" cubic equations using non-linear least squares, performed well both for males and females performed well in terms of Goodness of Fit, and also passed the diagnostic tests, upon the inclusion of AR terms. The results for the equations, male and female, on the Gini coefficients involve different equations in structural terms. The "best fit" equation of the male Ginis is downward sloping and linear with two dummy variables, associated with World War I and World War II. The intercept of 0.71 is relatively high value for the Gini coefficient, i.e. indicating relative inequality. The equation for the female Gini data differs, once again, from that for the males. The intercept of 0.58 is lower than that for males.

5. DISCUSSION

Several contributions have been made in this study. First, at a conceptual level, it has been shown that a concern for the quantity and distribution of suicide can be incorporated into quite conventional welfare economics. In other words the suicide prevention policies and strategies of a number of Western countries can be understood as a non-controversial dimension of the traditional discourse of modern welfare economics.

A second contribution lies in measurement: some emphasis has been placed on an alternative measure of the effect of suicide, the PYLL measure. Apart from its use as a component of the disability-adjusted life year (DALY) measure for the burden of disease industry associated with Murray and Lopez [70], this measure has not been widely applied. The health literature on suicide in Australia uses only data based on a simple count of suicides, and various quotients based on this count measure. The alternative PYLL measure has some useful quantitative characteristics which have been employed in some empirical work here.

TABLE 2: ESTIMATED TIME TRENDS, PYLL(75)$_{AS}$ RATE AND STANDARDISED MORTALITY RATE PER 100,000 POPULATION, SUICIDE, MALES AND FEMALES, AUSTRALIA, 1907-2003

	Male PYLL(75)$_{AS}$ Rate	Male SMR	Female PYLL(75)$_{AS}$ Rate	Female SMR
Intercept	0.20***	27.69***	0.03**	3.78**
	(6.03)	(12.67)	(2.69)	(3.61)
Time	-0.05***	-4.97**	0.01***	0.88**
	(-3.01)	(-2.27)	(3.02)	(1.86)
Time^2	-0.01***	0.83**	-	-0.08
	(-7.21)	(1.97)		(-1.78
Time^3	-0.01***	-0.04	-	-0.08
	(-7.21)	(-0.52)		(-1.78
DV1930-31	0.04**	4.99***	-	-
	(1.91)	(4.40)		
DV1941-51	-0.04**	-3.05***	-	-
	(-2.30)	(-3.14)		
DV1999-2003	-0.11***	-	-	-
	(-4.23)			
DV1962-2003	-	-	0.05***	-
			(3.50)	
DV1962-75	-	-	-	2.34**
				(4.45)
AR(1)	0.74***	0.88***	0.77***	0.76**
	(9.40)	(8.19)	(10.80)	(10.02
AR(2)	-	-0.22**	-	-
		(-2.06)		
Goodness of Fit				
Adj. R^2	0.98	0.83	0.94	0.85
F	887.71***	64.40***	503.38***	137.83

Notes: i. One, two and three asterisks indicate statistical significance at the ten, five and one per cent levels, respectively.

ii. *DV1930-31* is a dummy variable that takes the value of unity from 1930-1931, and so forth for *DV1941-51*, *DV1999-2003*, *DV1962-2003* and *DV1962-75*.

iii. *AR(1)* is the first-order coefficient of autocorrelation, and so forth.

iv. Data in parentheses are *t*-statistics. For the diagnostic tests, the *p*-values are in parentheses.

Source: Calculated from data in [72]

TABLE 3: ESTIMATED TIME TRENDS, COEFFICIENTS OF VARIATION AND GINI COEFFICIENTS ON STANDARDISED PYLL-AT-SUICIDE, MALES AND FEMALES, AUSTRALIA, 1907-2003

	COV Males	Gini Males	COV Females	Gini Females
Intercept	1.10***	0.71***	0.97***	0.58***
	(9.25)	(102.47)	(62.61)	(13.56)
Time	-0.22***	-0.01***	-0.00	-0.12***
	(-2.74)	(-4.98)	(0.07)	(-3.00)
$Time^2$	0.04***	-	-0.01**	0.04***
	(2.73)		(2.56)	(3.98)
$Time^3$	-0.002***	-	0.001***	-0.00***
	(-2.29)		(-4.13)	(-4.13)
DV1917-19	-	-0.09***	-	-
		(-4.20)		
DV1944-45		-0.15***	-	-
		(-6.02)		
AR(1)	-0.27***	-0.19***	0.34***	1.78***
	(-2.84)	(-1.18)	(3.40)	(15.09)
AR(2)	0.45***	-		-0.82***
	(4.80)		-	(-7.26)
MA(1)	-	-	-	-1.77***
				(-19.71)
MA(2)	-	-	-	0.87***
				(11.25)
Goodness of Fit				
Adj. R^2	0.91	0.33	0.42	0.77
F	186.90***	13.02***	18.48***	47.07***

Notes: See Notes to Table 2.
Source: Calculated from data in [72]

Suicide tended, formerly, (say, a century ago), to be an occurrence amongst older persons, male especially, but since the 1950s, circumstances have changed and suicide is now more prevalent among relatively younger people. While male suicide PYLLs are currently three to four times higher than female PYLLs, the female PYLL is now double the level of 100 years ago. Thus, it is important to describe accurately the trends in suicide activity by age.

The evidence provided in this paper demonstrates that the conventional approach to measurement, i.e. mortality rate measures of statistical location, do not "tell the whole story" about suicide. Rather, a key position adopted here is that, if death by suicide is to occur in any population, it is, generally speaking, better that these deaths occur as late in the life span as possible, with as little variation or dispersion in that late age as possible. Thus, it is "best", if suicide is to occur, that its

distribution by age is unequal, with the inequality concentrated at later age groups.[5] This paper presents conceptual explanations for measuring suicide by this alternative approach, which requires the calculation of PYLLs. The paper also produces empirical results of applying PYLL-based approaches to suicide. Note that PYLL-based measures ought to be regarded as an additional, complementary measure, not a substitute, for suicide rates.

Inequality is measured not just by statistical instruments, such as the COV, but also by other economic measures of inequality, such as the Gini coefficient, Lorenz curves and so forth. This study uses Gini coefficients, as well as COVs, in order to show that no single measure of inequality is sufficient. Such measures ought to be regarded as relevant to the age distribution of PYLL and also to the age distribution of deaths *per se*.

The reason for applying several measures of inequality to a distribution is that it is well established in the economic literature on measuring income inequality that each measure of inequality is based on implicit assumptions about the social welfare function [75] [76] [77] [73].

It seems that the current policy goal of averting the high level of youth suicide is unequivocal. Indeed we do not wish to undermine any such view. However, one must still be careful to ask what is foregone in pursuing a declining PYLL rate in a population, an implicitly attractive goal. Even if suicide policy were successful in achieving a declining PYLL rate, policy makers still need to be informed about the characteristics that have changed in the age distribution of PYLLs and the age distribution of deaths. There are important welfare implications behind trends in suicide and one must therefore approach the interpretation of trends in PYLL rates and distributions with caution.

This point is illustrated by Table 5, which provides seven cases (A to G) of illustrative data on PYLLs across four hypothetical age groups. The data are generated in order that the age distribution of PYLL across the cases varies but total PYLLs remains constant. The Table shows also how the age distribution of deaths due to suicide is associated with each of the seven PYLL distributions. Gini coefficients are calculated on the age distributions of both PYLLs and mortality, and show some of the disparities that exist across the cases. We do not wish to try to argue which of the seven PYLL distributions in Table 5 is ideal. We also do not want to attempt to rank these seven cases in order from best to worst. However, we do wish to argue for policy makers to be informed of all aspects of suicide policy. The approach to suicide measurement here is also particularly useful for making comparisons, such as those employed here through time or by gender (as shown here) or by locality, ethnic or income group and so forth. Being informed about the effectiveness of suicide policy requires suitable and sufficient measures of suicide.

This study provides a different "story" which can be told about Australia's experience of suicide reduction from that told by the suicide measures that are being conventionally applied.

[5] Whether or not PYLLs should be equal across age groups is not being suggested here.

The statistical work undertaken here is not conclusive. Statistical analysis has been undertaken to determine if the PYLL data exhibit periods of structural change that coincide with historical events or periods, e.g. war, depression etc. When people observe such time-series data, their minds quickly switch to "interpretation mode" seeking to explain the movements.

Further research is clearly necessary to answer other questions. The next step is to use this PYLL measure of suicide in a multi-factorial causal model to "explain" the suicide behaviour thus measured.

TABLE 4: SOME ILLUSTRATIVE DATA SHOWING SEVEN PYLL(100) DISTRIBUTIONS, AND RELATED MORTALITY DISTRIBUTIONS, BY AGE, AND THE GINI COEFFICIENT FOR EACH DISTRIBUTION

	0-19yrs	20-39yrs	40-59yrs	60-79yrs	80-99yrs	Total	Gini
PYLL							
A	500	500	500	500	500	2,500	0.00
B	0	0	0	0	2,500	2,500	0.80[iii.]
C	0	0	2,500	0	0	2,500	0.80[iii]
D	2,500	0	0	0	0	2,500	0.80[iii]
E	500	0	0	0	2,000	2,500	0.72
F	2,000	0	0	0	500	2,500	0.72
G	260	1,000	1,000	230	10	2,500	0.44
Deaths							
A	*6*	*7*	*10*	*17*	*50*	*100*	*0.44*
B	*0*	*0*	*0*	*0*	*250*	*250*	*0.80[iii.]*
C	*0*	*0*	*50*	*0*	*0*	*50*	*0.80[iii.]*
D	*28*	*0*	*0*	*0*	*0*	*28*	*0.80[iii.]*
E	*6*	*0*	*0*	*0*	*200*	*206*	*0.79*
F	*22*	*0*	*0*	*0*	*50*	75	*0.68*
G	*3*	*33*	*20*	*8*	*1*	*64*	*0.50*

Notes: i. For Gini coefficient calculations, zeros must be converted to an approximation of zero, e.g. 0.00000001.

ii. It is assumed that the cohort is a constant population of 100,000.

iii. That the Gini coefficient is not unity given that the data appear to be completely unequal is an artefact of there being a small number of observations.

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