RESEARCH COMMUNICATION

Study of Social Loss or Gain from a Particular Cause: Scope for the Developing Countries - a Review with Reference to Cancer

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Abstract

Incidence rates have long been used to assess the burden of different diseases in a population, whereas loss due to occurrence of diseases is studied using the death rates. Death rates however, are based on and therefore describe, only number of lives lost. There have been two approaches to arrive at the actual loss or gain from a particular cause viz. Person years of life lost (PYLL) approach and cause elimination life table (CELT) approach. This review covers these approaches and the competing risk theory and models focusing on the methodological developments. A summary of the conceptual and methodological developments on these concepts has also been presented. There are eight possible approaches in dealing with the loss in the presence or gain in the absence of a particular cause of death depending upon the preferences related to PYLL/CELT approach, modeling/descriptive approach, considering or without considering competing causes. A close look at the two basic approaches reveals that PYLL and cause elimination are just different terminologies used to address the same quantity, loss in the presence or gain in the absence. As far as descriptive vs. modeling approaches are concerned, all the descriptive procedures can be put in the form of models and all the models can be presented in a descriptive way. Regarding results using different models, no practical difference exists in the results based on different models for competing risks. However, exclusion of the competing risks may result in a considerable bias in the developing countries where general mortality is relatively higher. This review study suggests freedom in the selection of a modeling or a descriptive approach without any considerable loss of accuracy but at the same time emphasizes the consideration of the competing risks. An empirical study may be recommended to confirm the conclusions of this study.

Key Words: Cancer - loss or gain from a particular cause - person years of life lost - cause elimination life table - competing risk - modeling/descriptive approaches - developing countries

Introduction

There is a prominent worldwide geographic and ethnic varPrevention of cancer is the ultimate goal of any one directly or indirectly associated with the disease. For the planning of prevention measures and also for assessing the priorities however, knowledge of the burden and its magnitude in relation to other diseases is necessary. Incidence rates have long been used to assess the burden of different diseases in a population, whereas the loss due to the occurance of the diseases is studied using the death rates. Death rates however, are based on and therefore describe, only number of lives lost. They do not deal with the years or economically productive years of life lost due to the existence of different diseases. This particular problem with the death rates has given rise to the concept of loss or gain from a particular cause to facilitate the study of overall impact of a disease on the population.

There have been two approaches to arrive at the loss or gain from a particular cause viz. Person years of life lost (PYLL) approach and cause elimination life table (CELT) approach.

This review covers the concepts of person years of life lost approach (PYLL), cause elimination life table (CELT) approach and the competing risk theory and models focusing on the methodological developments. A summary of the conceptual and methodological developments on these concepts has also been presented.

Basic approaches

Figure 1 shows a diagrammatic presentation of the basic approaches in studying loss in the presence or the gain in the absence of a particular disease. Although there are two sub-approaches viz. PYLL and CELT of studying loss in the presence or the gain in the absence both appear

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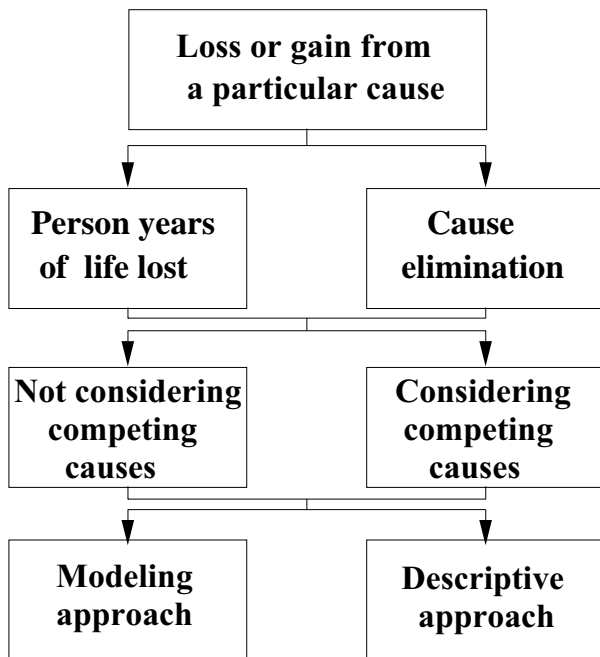
Figure 1. Flow Chart Showing the Approaches Adopted in Studying Loss or Gain from a Particular Cause

to be conceptually similar. However the two deal with different measures of same problem. PYLL approach deals with the person years of life lost or gained whereas cause elimination approach deals with the loss or gain in the expectation of life. The studies on both of these approaches can be further divided in two groups, those taking competing risks into consideration and those not taking competing risks into consideration. It appears that the two approaches have been adopted by two different group of researchers, although, there are some overlaps. By and large medical researchers have adapted the concept of productive years of life lost (PYLL) approach (main emphasis on simplicity in calculation and understanding on the cost of sacrifice in accuracy). Whereas the demographers and actuaries have adapted cause elimination life table (CELT) approach (main emphasis on accuracy in the estimation of quantity on the cost of complexity in calculation and understanding).

The origin of the concept of PYLL appears to be in 1940s when Dempsey (1947) stated "death rates fail to tell the entire story" to emphasize the public health importance of tuberculosis in USA even though the death rate from the disease was on decline. The origin of CELT approach on the other hand has a long history compared to the origin of PYLL. It was in 1761 when Daniel Bernoulli calculated the increase in the expectation of life from elimination of smallpox as a cause of death in the city of Wraclaw (Hakulinen, 1977). Since the development of these concepts, there has been extensive methodological as well as empirical work on these two approaches. Although the CELT approach was developed in eighteenth century, there is no evidence of any work in nineteenth century. According to Karn (1931), as the statistics on morbidity, mortality and population had not attained their present accuracy and extent no presuppositions existed for wide application of the models. Now since there is

improvement in statistics on morbidity and mortality even in the developing world, there appears a need for the methodological research on the concept of loss or gain to prioritize the diseases according to their public health importance. While doing the same, it is of utmost importance to have a thorough knowledge of the developments already taken place.

Before understanding about the application of PYLL or CELT, it would be necessary to have an understanding about concept of loss or gain and the various available procedures for defining the same.

Concept of Loss or Gain from a Particular Cause

Let us start with the question: What would happen if we were able to eradicate or eliminate a particular cause of death? Alternatively, equivalent question is "What is happening because we have not been able to eradicate or eliminate a particular cause of death?". In other words, the question is "What is the loss to the society due to the existence of a particular cause of death?". Alternatively equivalent question is "What would have been gain to the society if a particular cause of death was non-existent?". Subjectively, all these questions are different forms of same problem. They address towards same quantity of loss or gain associated with a particular cause of death. The next few paragraphs deal with the attempts made to define and estimate the concept of loss or gain from a particular disease.

One of the simple ways of defining the above could be that those died from particular cause would not die and the number of the deaths due to the particular cause would quantify the loss or the gain in this case. This quantity may present the most used answer to the above problem. However, this could be the answer while judging the burden of a disease in terms of death rates. The underlying assumption for the above simple answer is that the persons died due to a particular cause would not have died at all if the cause under consideration were not prevalent. But such an assumption might not be tenable. A person born has to die one or other day. In other words, immediate effect of discovering a way to cure a disease would be a reduction in the number of deaths by the number of people now dying from that cause. Within a short time, however, deaths from other causes may increase because of universal law of "destruction of any thing created" and the net long-term effect would be relatively small (Keyfitz, 1977).

An improvement to the question of defining of loss and gain could be that those died from a particular cause would not die at that age but will die at a certain predetermined age; say 65 years. Now loss or gain can be calculated by subtracting age at death from 65 years (the predetermined age at death) and then summing the differences for all the deaths under consideration. Some of the earlier studies of estimation of PYLL have adopted the above concept of using an arbitrary reference age (Dempsey, 1947; Dickinson and Welker, 1948; Haenszel, 1950). The underlying assumption here is that those dying from particular cause would die exactly at the age of 65

years in case that cause was non-existent. Another assumption is that the deaths after the age of 65 due to the considered cause do not cause any loss to the society. None of these assumptions is tenable. The second one is especially not tenable in the set up of developing countries where old people, although not being able to contribute much physically, are considered as guardian of the family and the moral inspiration to the next generation

A further improved approach for the definition of "loss or gain" could be that those died from a particular cause would not die at that age and will live the life equal to the expectation of life at that age. Now subtracting the age at death from the expectation of life at that age and then summing the differences for all the deaths under consideration can calculate loss or gain. This type of estimation procedure has been given by the studies judging the burden of disease through the concept of PYLL using expectation of life as reference age and some times by cause elimination life table approach (Murray and Axtell, 1974; Horm and Sondik, 1989). The underlying assumption here is that those dying from particular cause at certain age would live exactly equal to the expectation of life at that age in case that cause was non-existent. Conceptually the assumption seems to be very much valid and tenable. But it may be difficult to find the expectation of life of a person in the assumed absence of a particular cause. Strictly speaking, it may not be possible. Therefore the expectation of life in the normal situation is used. Some times a life table with mortality from all the causes other than the one under consideration have been constructed and expectations of life from these life tables have been used (Bonneux et al, 1998). The above procedure is based on the assumption that while arriving at expectation of life, that those died from particular cause would not die at all. Again this is not tenable assumption. Due to these limitations as a further refinement the role of the concept of competing risks was introduced.

A further refinement was that those died from a particular cause would not die at that age but will die from one of competing causes of death depending on the strength of various competing causes of death at the time of real death. This type of answer has been provided by the studies judging the burden of disease through the concept of PYLL or CELT approach considering competing risks from existing causes of death. Now, the task is to arrive at the intensity of the risks of different causes of death in the assumed absence of a particular cause. There have been broadly two approaches, modeling approach (Kannisto, 1947; Dorn, 1950; Kimball, 1958; Chiang, 1961) and empirical approach (Dhar, 1991; Mackenbach et al; 1997) for the above estimations. In modeling approach, we make certain assumptions about behavior of existing causes of death and arrive at the formula for probability of death from each cause in the assumed absence of a particular cause. In empirical approach, Ram and Dhar (1992) arrived at it descriptively by prorating the deaths due to the considered cause in a particular age group to the remaining competing causes of death in the age groups subsequent to that particular age group. Mackenbach et al (1997) used death certificate information to estimate the prevalence of competing

causes of death at the moment of dying from specific underlying causes of death.

The above approaches attempts to measure the loss or gain in terms of years of life irrespective of the quality of life. Portions of life lived in childhood, adulthood or in old age are not distinguished and therefore would get same weight. The way Dempsey (1947) argued that death rate fails to tell the entire story; one may argue that even PYLL or expectation of life lost/gained fails to tell the entire story, because the years of life in itself are not important for the society. In fact, the portion of life, that is active and productive, is useful and therefore important for the society. Thinking on this angle of the problem, researchers have arrived at various ways of deriving portion of life that is productive. Some have tried the concept of quality adjusted life years and some have looked at disability adjusted life years (Murray and Lopez, 1994; Meltzer et al, 1998). Some have even used work participation rate and derived working years of life lost (Dhar, 1991).

Approach of Person Years Life Lost (PYLL)

The term `potential years of life lost' has been used most often to refer to the above term of Person Years Life Lost. Dhar (1991) however, introduced the term person years of life lost. Reason is that former one gives impression that the years of life lost would have been useful or productive, if not lost. This is not true because the term potential is not same as active or productive and the assumption that the years of potential life lost, if saved, would have been active is hardly tenable (Arca et al, 1988).

As mentioned earlier, PYLL was developed in the 1940s and '50s, when the conventional mortality rate in its various forms was being criticized on the grounds that it was "influenced by the relative stability of the mortality rates at the older ages and does not permit sufficient weight to be given to the differences in the mortality at younger ages (Blane et al, 1990). Dickinson and Welker (1948) came out with two new measures, namely, 'life years lost' and 'working years lost' to decide the leading causes of death. Haenszel (1950) reviewed the publication of Dickinson and Welker and came out with standardized rate for mortality defined in units of lost years of life. These studies defined the PYLL as 'the total number of years lost through the failure of individuals to live some allotted life span and working years lost as the proportion of PYLL falling between the productive ages between 20 and 65'. Allotted life span has been defined in these studies as 65 or 75 years of life. Haenszel emphasized the standardization of lost years of life to facilitate the comparisons between different areas and time periods. He suggested this standardization in the same manner as standardized death rates. The reason for giving advantage to standardized PYLL was that standardized death rate is influenced by the relative stability of the mortality rates at the older ages and does not permit sufficient weight to be given to the differences in the mortality at younger ages.

Next advancement in the calculation of PYLL is the consideration of the theory of competing risks. In this approach, the expectation of life is derived in the assumed

absence of the cause of death under consideration, considering the intensity of other competing causes.

After the development in second quarter of the twentieth century, the concept of PYLL was used extensively in the fourth quarter . The main reasons for its importance and popularity are:

1. Foremost reason is that PYLL is very simple to calculate, understand and interpret. Its calculation requires as minimum information as just number of deaths by age.

2. This indicator fits well into the category of Social Indicators and can help health planners define priorities for the prevention of premature deaths (Romender and McWhinnie, 1977).

3. Use of PYLL points out that premature deaths are considerable problem that might be avoided by more directed health interventions (Glass, 1986).

4. It has advantages over mortality as a measure of public health significance of a disease (Mettlin, 1988).

5. PYLL data highlight the relative importance of those causes of death that currently subtract several potential years of life from individuals in comparison to the more common causes of death at older ages (Arca et al, 1988).

Terms similar to or related with the concept of PYLL
    Potential years of life lost (Dempsey, 1947)
    Life years lost (Dickinson and Welker, 1948)
    Working years lost (Dickinson and Welker, 1948)
    Person years of life lost (Ram and Dhar, 1992)
    Working years of life lost (Dhar, 1991)

Applications of the Concept of PYLL

A common application of PYLL is in ascertaining the burden/impact of a disease (Murray and Axtell, 1974; Richter, 1979; Castilla et al, 1993; Selik and Chu, 1997; Obiri et al, 1998) giving higher weight to the premature mortality and thereby ranking leading causes of death (Dempsey, 1947; Dickinson and Welker, 1948; Romender and Mcwhinnie, 1977; Mettlin, 1988; Dhar, 1991) and leading sites of cancer (Armstrong, 1988; Dhar, 1991; Murthy et al., 2002). Another common use of PYLL is in studying the trend in the burden of different causes (Mettlin, 1989; Tsai et al, 1991; CDC, 1992; Conti et al, 1997). There are studies calculating PYLL to compare the leading causes of death in different countries (Arca et al, 1988; Garcia and Cayolla, 1989). Blane et al (1990) calculated PYLL to examine British social class differences in mortality. Kuroishi et al (1990) used the concept of PYLL to study the effectiveness of a screening programme. Yuen et al (1997) calculated standardized PYLL ratio to study the geographical variation in the impact of female breast cancer. Krishnamurthy and Dhar (1991) calculated PYLL due to deaths in childhood in Mumbai to study the contribution of cancer and other diseases to premature mortality.

The Cause Elimination Lfe Table (CELT):

This approach deals broadly with the estimation of effect of elimination of a cause of death. The prevention of a disease is the primary goal of one associated with the health management. The estimation of the effect of elimination however, is a challenging problem from biological point of view. Because, the elimination of a particular disease not only saves years of life thereby enhancing the expectation of life, also saves money that is being spent on the diagnostic, treatment and other aspects of that disease. Studies dealing with the estimation of effect of elimination have been limited in the scope to the estimation of loss/gain in the expectation of life. This is probably because of the complexity and difficulties involved in the estimation of the other effects of elimination.

Further, it should be clarified that the concept of elimination of a particular cause of death is purely hypothetical. In practice, elimination means complete eradication of the causes of that disease. Generally, causes of a disease (specially of non-communicable diseases) are not specific to only that disease but also associated with many other diseases. For example, tobacco consumption, a significant cause of many cancers, is also associated with myocardial infarction. Thus in order to eliminate cancers attributable to tobacco, if we stop tobacco consumption, not only tobacco related cancer will be eliminated but also some of incidence and deaths due to myocardial infarction will get avoided. Thus it is really complex and difficult to estimate the complete effect of the elimination of a particular disease or cause of death.

As discussed earlier, cause elimination is another approach in addition to PYLL approach for studying the loss or gain from a particular health problem. PYLL quantifies the loss/gain in terms of years of life whereas cause elimination approach quantifies the same thing in terms of increase/decrease in expectation of life. Therefore like ordinary expectation of life, the increase or decrease in expectation of life is a hypothetical index, its not a real measure. Although both of the approaches have been used extensively in the last century, the origin of the cause elimination approach appears far earlier than that of PYLL. There is evidence of this concept being studied as early as 1761 when Daniel Bernoulli calculated the increase in the expectation of life from elimination of smallpox as a cause of death (Hakulinen, 1977). In the next century however, there is hardly any evidence of any work on this concept. This was due to the fact that the statistics on morbidity, mortality and population had not attained, even in the developed countries, the present accuracy and extent (Karn, 1931). As the accuracy and extent of data on incidence and mortality improved in the 20th century, there have been many studies looking at the impact of partial or complete elimination of a cause of death on the expectation of life. Most of the studies however, have been confined to the developed world.

Basic methodology in this approach involves the construction of two life tables; one, when all the causes of death are in force and two, when a particular cause of death is assumed to be eliminated completely or partially. Differences in the expectation of life in two circumstances are taken to quantify the loss or gain from a particular cause. The main task has been to estimate the expectation of life in the assumed absence of the considered cause of

death. The easiest and common way of estimating this expectation of life is to subtract the deaths of the considered cause from total deaths and apply these to construct a life table. Refinement to this method is the consideration of competing causes of death in arriving at expectation of life in the assumed absence of the considered cause of death. Thus, elimination of one or more causes of death completely or partially was the main requirement resulting in the development of the theory of competing risks. Also this fact along with the availability of accurate and complete statistics on morbidity and mortality in the developed world induced the development of many competing risk models. The theory of competing risks and models both have been discussed in detail in the following section.

Applications: This concept has been parallel to the concept of PYLL in application. Although origin of this concept is dated centuries earlier than that of PYLL, use of this approach is not as vast as that of PYLL. The most likely reason may be in the conceptual and computational simplicity attached to PYLL. The common applications have been in assessing gain in life expectancy after assumed elimination of a disease (Keyfitz, 1977; Tsai et al, 1978; Lai and Hardy, 1999), comparing the relative importance of different causes of death and ranking the different causes of death in terms of their effect on the society (Gupta and Rao, 1973; Mackenbach et al, 1999).

Competing risk theory and models

The theory of competing risks can be seen in parallel to the studies dealing with concept of loss or gain from a particular disease. Both the approaches of studying loss or gain, namely, PYLL and cause elimination, needed and therefore used the concept of theory of competing risks. Therefore the origin of theory of competing risks is as old as the cause elimination approach. The concept of competing causes was considered even in the first study dealing with cause elimination approach in 1761, when Daniel Bernoulli calculated that if it were possible to eliminate smallpox as a cause of death, the expectation of life at birth of an individual in the city of Wraclaw (Germany) would increase from 26 years 7 months to 29 years 7 months.

The theory of competing risks originates from the fact that death is an unavoidable event for any one born. That is why elimination of a particular cause raises the probability of death from other causes. Keyfitz (1977) rightly stated, the immediate effect of discovering a way to cure a disease would be a reduction in the number of deaths by the number of people now dying from that cause. Within a short time, however, deaths from other causes would increase, and the net long-term effect would be relatively small.

There are various causes of death that an individual has to fight to continue living. How long an individual lives, depends on many factors like, his health, environment, various diseases prevalent, etc. This theory has been most commonly considered while trying to study the impact of elimination of a particular cause on the population. Hakulinen (1977) puts the theory of competing risks this way; a living individual has several concurrent imaginary lives. Each of these lives is terminated by a certain (predetermined) cause of death. The length of the shortest of these lives becomes the real length of the individual's life and corresponding cause of death becomes the real cause of death of the individual. Thus, the theory of competing risks deals with the question "what mortality pattern, a person died from a specific cause, could have experienced, had the cause under consideration been eliminated from the population before that person's death?" Actually, all the theories on competing risks are based on various imaginations because no one can know the outcome of an imaginary event, i.e., an event that did not take place.

Probabilities in the theory of competing risks
Crude probability (Qir): Probability of death of an individual in the ith age group from cause R when all the causes of death are in force.
Net probability[1] (qir): Probability of death of an individual in the ith age group from cause R if only the cause R is active in the population .
Net probability[2] (qi.r): The probability of death of an individual in the ith age group when the cause R has been eliminated.
Partial crude probability (Qir.k): Probability of death of an individual in the ith age group from cause R when cause K has been eliminated.

Calculation of the crude and net probabilities
The calculation of the crude probability of death from a specific cause is quite simple because it requires data on mortality from the cause under consideration when all the causes are in force. Whereas the calculation of other two probabilities requires data on mortality on hypothetical elimination of one or more causes of death. Crude probability (Qir) of death from a specific cause R for ith age group can be calculated as following.

$$Qir = Dir / Pi$$

Where Dir is the no. of deaths due to cause R among the people in ith age group and Pi is the average population in ith age group.

Net probability (qir) of death in ith age group when all the causes of death except cause R are active, can not be calculated as they represent the probability of hypothetical events. However, we can estimate net probabilities using crude probabilities based on some assumptions about the behaviour of competing causes of death. There are many models in the literatue developed on their own assumptions about the competing causes of death. The distinction in the models relates mainly to assumption on which they have been based. Few popular models are as following.

Popular models in competing risks
As stated above, there are three types of probabilities in theory of competing risks; crude, partially crude and net probabilities. The models in the competing risks are all about speculating the biological behaviour of

competing causes and estimating the net probabilities. Models are nothing but mathematical presentation of various assumptions about some unknown phenomenon and its application on the problem of interest. In the theory of competing risks, assumptions are about the nature/intensity of competing causes of death in hypothetical absence of a particular cause of death. There are many models in the literature dealing with the theory of competing risks. Let us have a look at some of popular models dealing with competing risks. For details of the same, one may refer to respective references.

A common feature of the models is the division of observation period into small time intervals, presented here by i. Another common feature is that all deal with the probabilities defined above; crude, net and partially crude probability. The main problem with development of models is calculation of net and partially crude probabilities based on figures for a particular time interval.

General model (Independent risks)

Let there be Rk (k=1, 2, ..., c) causes of death affecting a population and let us assume that these causes of death are exhaustive. Let us attach a random variable Xk to each cause of death Rk such that Xk represents for each individual the time at which Rk would kill him. Now in case of each individual the shortest of Xk (k = 1, 2, ..., c) and corresponding cause Rk would be observable. Each one of the variables Xk does not necessarily have to be proper, i.e., each of the causes Rk does not necessarily have to be capable of killing all the possible individuals. General model for independent risks is based on the assumption that the variables X1, X2, ..., Xc are independent and the net and crude probability functions have derivatives (Hakulinen, 1977).

Kannisto's model

In order to calculate the consequences of elimination of a cause of death, Kannisto (1947) presented a model for the calculation of net probabilities based on crude probabilities. He derived the model under the assumption of proportionality of the net and crude probabilities: qik/qi.k = Qik/Qi.k

Additional assumption was that the variables (Xk), the time at which the cause K would kill the person, are independent, when qi = qik + qi.k - qik * qi.k
Formula: qik = (1 / 2) * [qi - {qi ** 2-4 * (qi - Qik) * Qik * qi} ** (1 / 2)] / (qi - Qik)

Dorn's model

According to Dorn (1950), the commonest way of estimating net probabilities was by treating the deaths due to other causes as withdrawals alive. Based on this, Dorn gave the following formula for the calculation of net and partially crude probabilities.
Formula: qik = Qik / [1 – (qi - Qik)/2]
    and Qih.k = Qih / (1 – Qik / 2)

Kimball's model

Kimball's (1958) model was based on the assumption that the probability of death from Rh when Rk has been eliminated equals the probability of death from Rh given

that the person does not die from Rk.
Formula: Qih.k = Qih/(1-Qik)
    qih = Qih[1-(qi-Qih)]

Chiang's model

Basic assumption in Chiang's (1961) original model was the identity of the forces of mortality which is in fact more general assumption than the assumption of the independence of the variables X1, X2, ..., Xc. However in 1970, Chiang made the assumption of independence also for the simplicity of formulae. His second basic assumption was that the quotients μk(t)/μ(t), k = 1, 2, ..., c, were constant in each interval (where μ(t) is the force of mortality at time t and μk(t) is the force of mortality from cause k at time t).
Formulae: qik = 1 – (1 – qi) ** (Qik/qi) Qih.k = [Qih / (qi - Qik)][1-(1-qi)**(1-Qik/qi)]

Ratio models

If we assume that Xk and X.k are independent, we have   qi = qik + qi.k + qik * qi.k
We also have qi = Qik + Qi.k
Therefore the main problem is of dividing the probability qik * qi.k between the two causes Rk and R.k. Let us assume that the share of R.k is h * qik * qi.k, (0 ≤ h ≤ 1), then we have

Qik = qik – h * qik * qi.k
    and
Qi.k = qi.k – (1-h) * qik * qi.k

Schwartz and Lazar (1964) derived the following solutions of the above equations under assumption that h does not explicitly depend on the net probabilities [cf Hakulinen, 1977].
qik = [1 – h*qi + Qik – {(1 – h*qi + Qik) ** 2 – 4*(1 - h) * Qik} ** (1 / 2)] / [2 * (1 - h)]

Various models corresponding to different values of (1-h)/h are known as ratio models.

Actually, PYLL can be defined as the years of life that would have been lived by the persons died from a particular cause in addition to the life already lived by them had the cause of death under consideration not in existence. Thus PYLL quantifies the years of life lost due to the deaths from a particular cause in a year. While comparing PYLL for different population or for the same population over a period of time, various rates in terms of population have been defined. Mathematically, the PYLL can be defined as the weighted sum of number of deaths at each age/age-group. Subtracting the age at death from a reference age derives weights. Reference age is considered to be the age that would have been attained by the person died had the cause of death not in existence. There are studies having used a fixed reference age for all the deaths. On the other hand, there are also studies having used varying reference age for the deaths in different age groups. There are many approaches in deciding the reference age. Some have used 65 or 75 years and some others have used expectation of life at birth as the fixed reference ages. On the other hand in varying reference age approach, most of times, expectation of life

corresponding to the age at death, so called local life expectancy (Barendregt et al, 1995), has been taken as reference age. To arrive at the expectation of life, some times all deaths have been used and some times all deaths minus particular cause deaths have been utilized in their place.

In addition to the above classical models, there are a few more approaches in arriving at net probabilities. Hakulinen (1977) suggested a product limit estimator. However, this is applicable only when the exact order of events is known, a condition usually satisfied only with relatively small populations. In applications concerning human data, however, observations are grouped and therefore PL estimators are not applicable. Dhar (1991) proposed a descriptive procedure by prorating the deaths from the considered cause to the higher age groups according to the intensity of other causes of death. The basic assumption was that risk of death from other causes would be same for those who died or did not die from the considered cause.

Summary

The methodological developments discussed above in this article deal with the measurement of the loss or gain from a particular disease. It may be stressed that the concept of elimination of a particular cause of death is purely hypothetical. In practice, diseases like cancer can be eliminated completely. Another aspect worth mention is the difference between the effect of the elimination estimated and the actual effects experienced. Effects will be multi-dimensional; increase in the person years lived, decrease in person years lived with disease (disable years), saving of the finance spent on the management and also effects on etiologically associated diseases.

The studies discussed above dealt with estimation of only one component of loss or gain from a particular cause; i.e., in terms of the years of life lived by the population. Other aspects have by and large eluded researchers attention, due to the complexity involved. In fact, there have been some attempts to adjust for disability in the form of disability adjusted life years (DALY) (Murray and Lopez, 1994). However, there have been many criticisms of the methods (Barendregt et al, 1995; Anand and Hanson, 1997; WHO, 1996) especially immediately after its development. Moreover, DALY has two components; years of life lost (YLL) and years of life with disability (YLD) and in the estimation of YLL, non-consideration of competing causes may be a concern in case of developing countries where general mortality is relatively high (Hakulinen and Teppo, 1976). Also the estimation of YLD requires estimates of incidence, duration and disability weights and the process of obtaining these is extremely resource intensive (Somerford and Katzenellenbogen, 2004). A detailed review of DALY is beyond the scope of this article.

While dealing with the concept of loss in the presence or gain in the absence of a particular cause of death two approaches appear; PYLL approach and CELT approach. Within each of these two approaches, there are both types of studies; considering and not considering the competing risks. Studies based on competing risks have considered competing causes of death while arriving at age at death or expectation of life in the absence of a particular cause of death. Other studies have ignored the competing causes and used a reference age in case of PYLL approach and used total deaths minus deaths from considered cause in case of CELT approach. Within each of four sub categories, there are studies having adopted descriptive approach and there are studies having adopted the modeling approach. Models in general possess the advantage of accuracy in results. Descriptive approaches on the other hand possess the advantage of simplicity in computations and in understanding and interpretation of results. Thus, there are eight possible approaches in dealing with the loss in the presence or gain in the absence of a particular cause of death. These are listed below.

1. PYLL descriptive approach without considering competing risks
2. PYLL descriptive approach considering competing risks
3. PYLL modeling approach without considering competing risks
4. PYLL modeling approach considering competing risks
5. CELT descriptive approach without considering competing risks
6. CELT descriptive approach considering competing risks
7. CELT modeling approach without considering competing risks
8. CELT modeling approach considering competing risks

A close view of each of the above reveals that PYLL and cause elimination are just different terminologies. As far as descriptive vs modeling approaches are concerned, all the descriptive procedures can be put in the form of models in a descriptive way. As far as different models are concerned, a general model for independent risks is not simple in calculations (Hakulinen, 1977). Regarding results using different models, no practical difference exists in the results based on different models for competing risks. However, exclusion of the competing risks may result in a considerable bias if the population under study has a high mortality (Hakulinen and Teppo, 1976). Another aspect that should be considered is the level of data available on morbidity and mortality. Although the concepts of cause elimination and competing risks were considered first in the 1700s, there were hardly any work on these concepts for the next one and half centuries. As per Karn (1931), statistics on morbidity, mortality and population had not attained their present accuracy and extent; no presuppositions existed for wide application of models. Similar may be the possible reason for the lack of the studies on these concepts in the developing countries. In conclusion, the above facts indicate freedom in the selection of a modeling or a descriptive approach without any considerable loss of accuracy but at the same time emphasize consideration of competing risks especially in the set up of developing countries where general mortality is relatively high Although the subjective conclusions of this study, appear conceptually quite sound, however, an empirical confirmation of the same may be recommended.

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