RESEARCH ARTICLE

What is the Most Suitable Time Period to Assess the Time Trends in Cancer Incidence Rates to Make Valid Predictions - an Empirical Approach

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Abstract

Projections of cancer cases are particularly useful in developing countries to plan and prioritize both diagnostic and treatment facilities. It also helps in formulation of corresponding appropriate Government policies and budget allocation. Projection of cancer burden means a systematic way of prediction of number of cases for cancer in general or for specific sites for a specific period of time. One of the simplest ways to predict the cancer cases for the current period is to use the latest crude incidence rate and superimpose it on the latest population. However, when the question is to predict the cancer cases for the future period after 3 years, 5 years or after 10 years, it becomes imperative to use the knowledge of past time trends in incidence rates as well as in population at risk. In most of the recently published studies the duration for which the time trend was assessed was more than 10 years while in few studies the duration was between 5-7 years. This raises the question as to what is the optimum time period which should be used for assessment of time trends and projections. Thus, the present paper explores the suitability of different time periods to predict the future rates so that the valid projections of cancer burden can be done for India. The cancer incidence data of selected cancer sites of Bangalore, Bhopal, Chennai, Delhi and Mumbai PBCR for the period of 1991-2009 was utilized. The three time periods were selected namely 1991-2005; 1996-2005, 1999-2005 to assess the time trends and projections. For the five selected sites, each for males and females and for each registry, the time trend was assessed and the linear regression equation was obtained to give prediction for the years 2006, 2007, 2008 and 2009. These predictions were compared with actual incidence data. The time period giving the least error in prediction was adjudged as the best. The result of the current analysis suggested that for projections of cancer cases, the 10 years duration data are most appropriate as compared to 7 year or 15 year incidence data.

Keywords: Projection - cancer incidence rate - trend - time period - empirical approach - India

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Introduction

Projections of cancer cases are particularly useful in developing countries to plan and prioritize both diagnostic and treatment facilities. It also helps in formulation of corresponding appropriate Government policies and budget allocation. Projection of cancer burden means a systematic way of prediction of number of cases for cancer in general or for specific sites for a specific period of time. One of the simplest ways to predict the cancer cases for the current period is to use the latest crude incidence rate and superimpose it on the latest population. However, when the question is to predict the cancer cases for the future period after 3 years, 5 years or after 10 years, then it becomes imperative to use the knowledge of time trends in incidence rates as well as in population at risk.

Recently, NCRP has published a report on Time Trends in Cancer Incidence Rates (NCRP 2013). This report depicts the changes in incidence rates of cancer from 13 Population Based Cancer Registries. In the fifth chapter of the report, an attempt is made to project the number of cancer cases at India level for selected leadings sites. Three approaches were used in the report to assess the time trend namely by i) Incidence rates by single years ii) Incidence rates by three years range and iii) Incidence rates by five years range. However, the important question remains as to which approach is suitable. Further, in view of around 25 years cancer incidence data being now available with NCRP for at least five cancer registries, the question arises as to which time period should be appropriate to assess the time trend so that meaningful projections are made. Further review of literature suggests that the cancer sites that are published related to assessment of time trends, in past three years, are related to Breast cancer (Moradpour et al., 2013; Wu et al., 2014), Cervix cancer (Boo et al., 2011), Ovarian cancer (Wang et al., 2014), Esophageal cancer (Kiadaleri, 2014), Lung cancer (Moradpour et al., 2013; Hashimi et al., 2014), Stomach cancer (Moradpour et al., 2013). In most of these studies the duration for which the time trend was assessed was more than 10 years while in few studies (Li et al., 2011; Kiadaliri et al., 2014; Wu et al., 2014), the duration was between 5-7 years. Thus, the present paper attempts to examine the suitability of different time periods to predict the future rates so that the valid projections of cancer burden can be done for India.
**Materials and Methods**

The cancer incidence data of selected cancer sites of Bangalore, Bhopal, Chennai, Delhi and Mumbai PBCR for the period of 1990-2009 was utilized. The five cancer sites selected for males were: Lung, tongue, mouth, prostate and NHL. The five sites selected for females were: Breast, cervix, ovary, gall-bladder and lung. The three time periods selected were namely 1991-2005; 1996-2005, 1999-2005. For the five selected sites, each for males and females and for each of the registry, the time trend was assessed and the linear regression equation was obtained to give predictions for the years 2006, 2007, 2008 and 2009. Thus, in total 50 predictions were available for each of the selected time periods. These predictions were compared with actual incidence data and errors were obtained in each case. For each site, based on the sum of squared errors, the time periods are ranked as 1, 2 and 3. The time periods which corresponded to the least squared error was ranked as 1 and the time period which gave the maximum squared error was given the rank as 3. The ranks were pooled for all the 50 predictions. Based on pooled ranks, the time periods were judged as 1, 2 or 3.

**Results**

The Comparison of Predicted Incidence Rates with Actual Incidence Rates for selected cancer sites and years (2006-2009) based on the incidence rates of 4 years period (P15) is shown for Bangalore Registry in Table 1. The difference between actual and predicted incidence rates for selected 4 years indicates the extent of errors that is occurring by projections. The squared sum of errors for Breast (209.0), Cervix (155.1), Ovary (8.6), Gall bladder (0.2) and Lung (7.3) is shown in the last row of the Table 3.

In order to know which time period is most suitable for prediction, the sum of squared errors for selected 4 years is tabulated for five cancer sites and three periods and shown in Table 4. For Bangalore registry, the period P7 (7 years

| Year | Incidence | Breast | Cervix | Ovary | Gall bladder |
|------|-----------|--------|--------|-------|--------------|
| 2006 | P15 Predicted | 29.3 | 15.2 | 6.4 | 1.2 | 3.0 |
|      | Actual    | 35.0 | 21.6 | 7.4 | 1.5 | 3.6 |
|      | Difference | 5.7 | 6.4 | 1.0 | 0.4 | 0.6 |
| 2007 | P15 Predicted | 29.9 | 14.4 | 6.5 | 1.2 | 3.1 |
|      | Actual    | 39.9 | 21.5 | 8.7 | 1.6 | 4.3 |
|      | Difference | 10.0 | 7.1 | 2.1 | 0.4 | 1.2 |
| 2008 | P15 Predicted | 30.5 | 13.7 | 6.7 | 1.2 | 3.2 |
|      | Actual    | 37.6 | 19.2 | 8.4 | 1.4 | 5.1 |
|      | Difference | 7.1 | 5.5 | 1.7 | 0.2 | 1.9 |
| 2009 | P15 Predicted | 31.2 | 12.9 | 6.8 | 1.3 | 3.3 |
|      | Actual    | 36.2 | 18.7 | 7.0 | 1.7 | 4.7 |
|      | Difference | 5.1 | 5.8 | 0.2 | 0.4 | 1.4 |

**Table 2. Comparison of Predicted Incidence Rates with Actual Incidence Rates for Selected Years (2006-2009) for the P10 period - Bangalore**

| Year | Incidence | Breast | Cervix | Ovary | Gall bladder |
|------|-----------|--------|--------|-------|--------------|
| 2006 | P10 Predicted | 32.2 | 17.7 | 6.5 | 1.3 | 3.7 |
|      | Actual    | 35.0 | 21.6 | 7.4 | 1.5 | 3.6 |
|      | Difference | 2.8 | 3.9 | 0.9 | 0.3 | 0.1 |
| 2007 | P10 Predicted | 33.3 | 17.4 | 6.7 | 1.3 | 3.9 |
|      | Actual    | 39.9 | 21.5 | 8.7 | 1.6 | 4.3 |
|      | Difference | 6.7 | 4.1 | 2.0 | 0.2 | 0.4 |
| 2008 | P10 Predicted | 34.4 | 17.1 | 6.9 | 1.4 | 4.1 |
|      | Actual    | 37.6 | 19.2 | 8.4 | 1.4 | 5.1 |
|      | Difference | 3.2 | 2.1 | 1.5 | 0.0 | 1.0 |
| 2009 | P10 Predicted | 35.5 | 16.7 | 7.1 | 1.4 | 4.3 |
|      | Actual    | 36.2 | 18.7 | 7.0 | 1.7 | 4.7 |
|      | Difference | 0.7 | 2.0 | 0.1 | 0.2 | 0.3 |

**Table 3. Comparison of Predicted Incidence Rates with Actual Incidence Rates for Selected Years (2006-2009) for the P7 period - Bangalore**

| Year | Incidence | Breast | Cervix | Ovary | Gall bladder |
|------|-----------|--------|--------|-------|--------------|
| 2006 | P7 Predicted | 32.3 | 18.8 | 6.5 | 1.1 | 3.8 |
|      | Actual    | 35.0 | 21.6 | 7.4 | 1.5 | 3.6 |
|      | Difference | 2.7 | 2.8 | 0.9 | 0.4 | 0.3 |
| 2007 | P7 Predicted | 33.4 | 18.7 | 6.6 | 1.1 | 4.1 |
|      | Actual    | 39.9 | 21.5 | 8.7 | 1.6 | 4.3 |
|      | Difference | 6.5 | 2.8 | 2.0 | 0.4 | 0.2 |
| 2008 | P7 Predicted | 34.6 | 18.7 | 6.8 | 1.1 | 4.3 |
|      | Actual    | 37.6 | 19.2 | 8.4 | 1.4 | 5.1 |
|      | Difference | 3.0 | 0.5 | 1.6 | 0.2 | 0.8 |
| 2009 | P7 Predicted | 35.7 | 18.6 | 6.9 | 1.2 | 4.6 |
|      | Actual    | 36.2 | 18.7 | 7.0 | 1.7 | 4.7 |
|      | Difference | 0.5 | 0.1 | 0.1 | 0.5 | 0.1 |

**Table 4. Comparison of Predicted Incidence Rates with Actual Incidence Rates for Selected Years (2006-2009) for the P15 period - Bangalore**

| Year | Incidence | Breast | Cervix | Ovary | Gall bladder |
|------|-----------|--------|--------|-------|--------------|
| 2006 | P15 Predicted | 29.3 | 15.2 | 6.4 | 1.2 | 3.0 |
|      | Actual    | 35.0 | 21.6 | 7.4 | 1.5 | 3.6 |
|      | Difference | 5.7 | 6.4 | 1.0 | 0.4 | 0.6 |
| 2007 | P15 Predicted | 29.9 | 14.4 | 6.5 | 1.2 | 3.1 |
|      | Actual    | 39.9 | 21.5 | 8.7 | 1.6 | 4.3 |
| May } | Difference | 10.0 | 7.1 | 2.1 | 0.4 | 1.2 |
| 2008 | P15 Predicted | 30.5 | 13.7 | 6.7 | 1.2 | 3.2 |
|      | Actual    | 37.6 | 19.2 | 8.4 | 1.4 | 5.1 |
| May } | Difference | 7.1 | 5.5 | 1.7 | 0.2 | 1.9 |
| 2009 | P15 Predicted | 31.2 | 12.9 | 6.8 | 1.3 | 3.3 |
| May } | Actual    | 36.2 | 18.7 | 7.0 | 1.7 | 4.7 |
| May } | Difference | 5.1 | 5.8 | 0.2 | 0.4 | 1.4 |

The squared sum of errors for breast (59.1), cervix (15.7), ovary (7.7), gall bladder (0.7) and lung (0.7) is shown for Bangalore Registry in Table 3.
What is the Most Suitable Time Period to Assess Time Trends in Cancer Incidence Rates - An Empirical Approach

The current study was designed to explore this question, using an empirical approach. Five sites each were chosen and using different time periods, predictions were done and compared with actual observations for four consecutive years (2006-2009). The errors were calculated for each period. It may be pointed out that five registries, five cancer sites and four different years give a total of 200 error observations were available to validate for each period so that the best time period can be chosen to assess the time trend.

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It may be noted that for a given registry, a time period was adjudged as best if the sum of errors for predictions corresponded to the lowest value among the three time periods. However, while pooling for registries, the ranks were pooled and the decision was made as to which time period is the best if the sum of errors for predictions rise to 100 observations. Thus, for male and females, a total of 200 error observations were available to validate for each period so that the best time period can be chosen to assess the time trend.

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Table 4. Pooled Square Differences According to Three Selected Time Periods-Bangalore

| Time Period | Breast | Cervix | Ovary | Gall | Lung | Total |
|-------------|--------|--------|-------|------|------|-------|
| P15         | 209.0  | 155.1  | 8.6   | 0.4  | 7.3  |       |
| P10         | 63.3   | 40.9   | 7.0   | 0.2  | 1.2  |       |
| P7          | 59.1   | 15.7   | 7.7   | 0.7  | 0.7  |       |

Table 5. Rank Based on Square Errors By Selected Sites, Periods and Cancer Registries - Females

| Registry   | Period | Tongue | Cervix | Ovary | Lung | TOTAL |
|------------|--------|--------|--------|-------|------|-------|
| Bangalore  | P15    | 3      | 3      | 3     | 2    | 14    |
|            | P10    | 2      | 2      | 1     | 1    | 8     |
|            | P7     | 1      | 1      | 2     | 3    | 8     |
| Bhopal     | P15    | 3      | 1      | 3     | 3    | 11    |
|            | P10    | 1      | 2      | 1     | 3    | 8     |
|            | P7     | 2      | 3      | 2     | 2    | 11    |
| Chennai    | P15    | 3      | 1      | 3     | 1    | 9     |
|            | P10    | 3      | 3      | 3     | 1    | 12    |
|            | P7     | 1      | 2      | 3     | 1    | 10    |
| Delhi      | P15    | 3      | 2      | 1     | 1    | 9     |
|            | P10    | 1      | 2      | 1     | 2    | 8     |
|            | P7     | 3      | 1      | 2     | 3    | 10    |
| Mumbai     | P15    | 2      | 3      | 3     | 1    | 11    |
|            | P10    | 2      | 1      | 2     | 3    | 10    |
|            | P7     | 1      | 3      | 3     | 1    | 11    |
| Pooled     | P15    | 12     | 11     | 12    | 9    | 56    |
|            | P10    | 10     | 6      | 9     | 12   | 45    |
|            | P7     | 9      | 12     | 12    | 6    | 49    |

Table 6. Rank Based on Square Error By Selected Sites, Periods and Cancer Registries - Males

| Registry   | Period | Tongue | Cervix | Ovary | Gall | Lung | TOTAL |
|------------|--------|--------|--------|-------|------|------|-------|
| Bangalore  | P15    | 3      | 3      | 3     | 2    | 3    | 14    |
|            | P10    | 2      | 2      | 1     | 1    | 2    | 8     |
|            | P7     | 1      | 1      | 2     | 3    | 1    | 8     |
| Bhopal     | P15    | 3      | 1      | 3     | 3    | 11    |
|            | P10    | 1      | 2      | 1     | 3    | 8     |
|            | P7     | 2      | 3      | 2     | 2    | 11    |
| Chennai    | P15    | 3      | 1      | 3     | 1    | 9     |
|            | P10    | 2      | 3      | 3     | 1    | 12    |
|            | P7     | 1      | 2      | 3     | 1    | 10    |
| Delhi      | P15    | 3      | 2      | 1     | 1    | 9     |
|            | P10    | 1      | 2      | 1     | 2    | 8     |
|            | P7     | 3      | 1      | 2     | 3    | 10    |
| Mumbai     | P15    | 1      | 1      | 2     | 3    | 9     |
|            | P10    | 2      | 1      | 2     | 3    | 10    |
|            | P7     | 1      | 3      | 3     | 1    | 11    |
| Pooled     | P15    | 12     | 11     | 12    | 9    | 56    |
|            | P10    | 10     | 6      | 9     | 12   | 45    |
|            | P7     | 9      | 12     | 12    | 6    | 49    |

Table 7. Overall Rank Based on Pooled Ranks of Males and Females Cancer Sites

| Period | Females | Males | Pooled | Over All Rank |
|--------|---------|-------|--------|--------------|
| P15    | 56      | 45    | 101    | 2            |
| P10    | 45      | 46    | 91     | 1            |
| P7     | 49      | 56    | 105    | 3            |

Discussion

Projections of cancer cases are particularly useful in developing countries to plan and prioritize both diagnostic and treatment facilities. The two approaches which are commonly used now-a-days in assessment of trends in cancer incidence cases are joinpoint (Joinpoint Regression Program, 2009) and linear regression approach. approach. Different authors tend to use different time periods for assessment of trend. While most of the studies use more than 10 years data to study the time trends while few studies also use lesser time periods ranging between 5-7 years (Li et al., 2011; Kiadaliri et al., 2014; Wu et al., 2014). These raises a question as to whether the period of 5-7 years is sufficient to assess the time trends and if so what is the method to validate it? If it is felt that the period of 5-7 years period is not sufficient then what is the minimum time period which should be adopted to study the trends so that meaningful projections are done from that.

The current study was designed to explore this question, using an empirical approach. Five sites each were chosen and using different time periods, predictions were done and compared with actual observations for four consecutive years (2006-2009). The errors were calculated for each period. It may be pointed out that five registries, five cancer sites and four different years give rise to 100 observations. Thus, for male and females, a total of 200 error observations were available to validate for each period so that the best time period can be chosen to assess the time trend.

It may be noted that for a given registry, a time period was adjudged as best if the sum of errors for predictions corresponded to the lowest value among the three time periods. However, while pooling for registries, the ranks were pooled and the decision was made as to which time period is the best. In order to overrule the influence of errors observed in one registry over the pooled results, the rank approach was thought better and logical. In other words, the pooling of ranks indicates as to on an average which time period is best. Going by overall results, it appears that P10 period is the best period for projections (Table 7).

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