Setting Outcome Targets for the National Cervical Screening Programme

A report for the
National Screening Unit

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Executive Summary

Mandate

In December 2002 the NCSP sought assistance from PHI in resetting the Ministry's outcome targets for cervical cancer incidence and mortality. These targets had been set in 1994 and were due to expire in 2005 (Ministry of Health 2002a).

The development by the NSU of a five-year strategic plan for 2003–2008 provided an opportunity to reset these targets.

Modelling approach

In this report we recommend revised targets based on classical age-period-cohort (APC) modelling of cervical cancer incidence and mortality. Such models do not model substantive variables explicitly, but use the three time dimensions as proxies. In particular, in our model important programme variables such as coverage and quality are captured mainly as a period effect.

Data

Unit record data from the cancer registry is used. Squamous and all cervical cancer are modelled separately.

The data is modelled in five-year age groups and five-year periods (quinary quinquennia). Incidence data is modelled from 1964 to 1998 and mortality is modelled from 1970 to 1999.

Mid-year population estimates between 1964 and 2001, and projections based on the 1996 census for the years 2002 to 2014, were obtained from Statistics New Zealand (SNZ). Māori population projections were based on the 2001 census. Two denominators were used to derive incidence and mortality rates:

1. All female person-years in the age groups modelled; and
2. Hysterectomy-adjusted female person-years in the age groups modelled.

When deriving incidence and mortality rates, the denominator should reflect the population at risk. Women who have had a hysterectomy and are therefore at negligible risk of cervical cancer should be excluded.

The hysterectomy-adjusted population was obtained by modelling hysterectomy prevalence in New Zealand women between 1964 and 1999 using a lifetable method. Hysterectomy-adjusted population projections are based on the 2001 census population.

Methods

Classical age-period-cohort (APC) models were used to analyse incidence and mortality data.

Multiple scenarios were modelled to assess the effectiveness of the screening programme, namely:

1. The ***optimal*** scenario, where we assume current trends will continue into the future. In other words incidence and mortality rates are forecasted by projecting period and cohort effects using simple linear regression on the last three periods and birth cohorts (Osmond 1985). The projected incidence and mortality rates obtained under this scenario[1] are highly optimistic, and somewhat unrealistic (at least for non-Māori women) since they assume no saturation of programme coverage.

2. The ***business as usual*** *(BAU)* scenario, where we assume that no further improvement in programme coverage or quality occurs, over and above what is already in place. This is modelled by assuming that period effects stabilise (or remain at the same level) after the last modelled period.[2] Cohort effects are still modelled using linear regression on the last three birth cohorts.

3. The ***target*** scenario, which is used to actually set the incidence and mortality targets. Projected period effects are assumed to track halfway between the optimal and BAU scenarios.

4. The ***counterfactual*** scenario, where we model what would have happened in the absence of the screening programme. This scenario is modelled by applying the APC model to a reduced dataset in which the last period modelled precedes the period when the screening programme commenced (approximately 1991). In other words, rather than modelling the 1990s we project period and cohort effects for this decade using linear regression. Since this assumes that historical trends for the 1960s to 1980s will continue into the future, rates projected under this scenario indicate what would have happened had there been no screening programme.

The number of incident cases and deaths averted due to screening (and treatment improvements in the case of mortality) are then estimated by comparing the target and counterfactual scenarios.

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1 This was the scenario modelled in *Cancer in New Zealand: Trends and Projections* (Ministry of Health 2002) for consistency with other cancer sites.

2 Note that there is an implicit assumption here that the screening programme is purely a period effect, and hence no additional screening measures translate to stabilising period effects.

Due to the poor quality of Māori data as well as varying ethnicity definitions over the modelled periods, Māori women are not modelled separately. Instead, Māori rates are modelled by examining the ratio of Māori cervical cancer cases and deaths, corrected for undercount using adjusters derived by record linkage, to total cases and deaths over the 1991 to 1999 period. These proportions are then applied to the projected numbers of cervical cancer cases (or deaths) in the population (from the APC model) to obtain an estimate of the number of Māori cervical cancer cases (or deaths), which in turn are used to derive the targets for this ethnic group.

Rates for non-Māori are modelled in the same way as described above for Māori, using one minus the estimated Māori proportion.

The ethnicity concept used is prioritised ethnicity (ie, for Māori, the total ethnic group concept).

Results

Recommended targets

Targets are provided for all cervical cancer and for squamous cancer, for both hysterectomy-adjusted and unadjusted populations, for all women and for Māori and non-Māori women.

Targets for 2006 and 2011 are derived from the APC model using forecasts for the 2004–08 and 2009–13 periods for incidence and the 2005–09 and 2010–14 periods for mortality[3] respectively. Only targets for 2006 and 2011 are presented in this report. Targets for 2008 could be derived by simply interpolating between the 2006 and 2011 targets.

Target rates are initially expressed per 100,000 women in age groups at risk, not for females of all ages. For incidence, the age range at risk is considered to be 25–79, while for mortality adult women of all ages are considered at risk (ie 25+).

The recommended age-standardised targets appear very different from the existing targets. This is because the existing targets are expressed per 100,000 females of all ages (0–100+), whereas the recommended targets are age-restricted as explained above. Also (though less importantly), the reference populations for direct age standardisation are slightly different (Segi's for existing targets, WHO World for the recommended targets).

In order to facilitate comparison with the existing targets, the recommended targets expressed as rates per 100,000 females of all ages (0–100+), standardised to Segi's world population, are also provided (in parentheses).

[3] The centre of the mortality periods are actually 2007 and 2012, but for consistency with the incidence targets these may be considered to apply to 2006 and 2011 respectively with relatively little inaccuracy introduced.

The age-standardised targets are summarised in Tables 1–3.

Table 1: Age-standardised targets for all New Zealand women

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	**Unadjusted population**	**Hysterectomy-adjusted population**	**Unadjusted population**
2006 Incidence	**18.1** (9.6)	**15.9** (8.4)	**14.9** (7.9)	**13.1** (6.9)
2006 Mortality	**6.0** (3.1)	**4.9** (2.6)	**5.3** (2.8)	**4.4** (2.3)
2011 Incidence	**16.7** (8.8)	**14.8** (7.8)	**13.5** (7.1)	**11.8** (6.3)
2011 Mortality	**5.2** (2.7)	**4.3** (2.3)	**4.5** (2.4)	**3.7** (2.0)

Note: Rates in bold are per 100,000 women aged 25–79 years for incidence and 25+ years for mortality, standardised to WHO world population. Rates in (parentheses) are per 100,000 females aged 0–100+, standardised to Segi population.

Table 2: Age-standardised targets for Māori women

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	**Unadjusted population**	**Hysterectomy-adjusted population**	**Unadjusted population**
2006 Incidence	**31.0** (16.4)	**27.1** (14.3)	**25.5** (13.5)	**22.9** (12.1)
2006 Mortality	**20.2** (10.6)	**16.7** (8.8)	**18.1** (9.5)	**17.5** (9.2)
2011 Incidence	**26.1** (13.8)	**23.8** (12.6)	**21.8** (11.5)	**19.4** (10.3)
2011 Mortality	**15.6** (8.2)	**13.1** (6.9)	**13.7** (7.2)	**14.1** (7.4)

Note: Rates in bold are per 100,000 women aged 25–79 years for incidence and 25+ years for mortality, standardised to WHO world population. Rates in (parentheses) are per 100,000 females aged 0–100+, standardised to Segi population.

Table 3: Age-standardised targets for non-Māori women

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	**Unadjusted population**	**Hysterectomy-adjusted population**	**Unadjusted population**
2006 Incidence	**16.7** (8.9)	**14.7** (7.8)	**13.8** (7.3)	**12.0** (6.3)
2006 Mortality	**4.7** (2.5)	**3.9** (2.1)	**4.2** (2.2)	**3.3** (1.7)
2011 Incidence	**15.7** (8.3)	**13.7** (7.3)	**12.6** (6.7)	**10.9** (5.6)
2011 Mortality	**4.2** (2.2)	**3.5** (1.8)	**3.7** (1.9)	**2.8** (1.5)

Note: Rates in bold are per 100,000 women aged 25–79 years for incidence and 25+ years for mortality, standardised to WHO world population. Rates in (parentheses) are per 100,000 females aged 0–100+, standardised to Segi population.

Screening impact to date

Estimates of the cumulative number of incident cases and deaths averted by screening (to 2003 for incidence and 2004 for mortality) are summarised in Table 4.

Table 4: Cumulative cases and deaths averted due to screening to date[4]

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	**Unadjusted population**	**Hysterectomy-adjusted population**	**Unadjusted population**
Cases averted	2044	1978	2653	2587
Deaths averted	522	498	542	522

Using the model for squamous cancer and the hysterectomy-adjusted population, we estimate that from the early 1990s, screening (formal and informal) has prevented approximately 2650 cases of invasive cervical cancer and (together with improvements in medical treatment) has avoided approximately 540 premature deaths among New Zealand women.

[4] Note that there is a slight discrepancy between the number of cases and deaths averted when the denominator is adjusted to reflect the hysterectomy-adjusted population. This is because the number of cases is derived by multiplying the incidence or mortality rate by the appropriate population denominator (which is different for hysterectomy-adjusted populations).

Also, in theory, the number of all cervical cancer cases and deaths must be greater than or equal to the number of squamous cases and deaths averted. However, this is not the case in Table 4. The reason is that the squamous and all cervical cancers series are modelled separately, and yield different rates, and hence a different number of estimated cases. The number of squamous cases and deaths is therefore, not dependent upon the number of all cervical cancer cases and deaths.

Other findings of note

The 'rebound' phenomenon

The BAU scenario shows that, if no further improvement in programme coverage and quality occurs over and above what is currently in place, then (age-standardised) incidence rates will soon begin to increase once more. This 'rebound' phenomenon is due to cohort effects.

This has major implications for the NCSP: it implies that substantial improvements will have to be made just to maintain the gains of the past decade, never mind to further reduce incidence rates and counts. At the same time, limits are placed on the extent to which programme coverage can further improve, at least among non-Māori women. The cohort effect together with the coverage saturation effect explains why the recommended targets anticipate only limited further gains (in terms of incidence) at best.

Mortality treatment effect

Unlike incidence, mortality rates appear to decrease irrespective of whether or not there is a screening programme in place. However, the decrease is much greater with the screening programme. Intuitively this finding makes sense, in that there exist effective medical treatments for cervical cancer, provided it is detected early enough. Hence, irrespective of the screening programme, we can expect cervical cancer mortality to decline due to therapeutic advances. In our model, the mortality period effect encompasses both treatment and screening effects, and this is also reflected in the recommended mortality targets.

Summary of 'key' targets

Throughout this report we have presented targets derived using different numerators and denominators (ie, using hysterectomy-adjusted versus unadjusted denominators and squamous versus all cervical cancers numerators). We recommend that the NCSP should place most emphasis on the targets obtained by modelling the squamous series and using a hysterectomy-adjusted population. These targets are summarised in Tables 5–8 below, both for the whole at-risk population (age-standardised rates) and for individual age groups (age-specific rates). The 'key' targets are also presented in Appendix 5 (page 72), expressed both as rates and as counts.

Linking outcome to performance targets

The recommended incidence targets for 2011 correspond to the achievement of an overall coverage level of 85% (hysterectomy adjusted) together with high standards of quality throughout all stages of the screening pathway.

Targets accepted after consultation

Following completion of the modelling reported here, the NCSP undertook a round of consultation with its expert advisors and other stakeholders, with the following outcome:

- While detailed targets, as recommended in this report, will be useful for NCSP planning and evaluation internally, a small set of 'headline' targets selected from the 'menu' provided would be suitable for external reporting.
- The headline targets will be restricted to all cervical cancers combined, and will be expressed solely in terms of directly age standardised rates, to include females of all ages and using Segi's as the standard population. For international comparability, rates will not be hysterectomy adjusted.
- Separate targets will not be set for Maori and nonMaori women.
- Incidence and mortality targets will be set 60% toward the optimal scenario, rather than halfway between business as usual and optimal scenarios.

The accepted headline targets are shown in Table 9 (page xiv).

Table 5: Summary of key age-standardised targets (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
Total population	**14.9** (7.9)	**13.5** (7.1)	**5.3** (2.8)	**4.5** (2.4)
Māori	**25.5** (13.5)	**21.8** (11.5)	**18.1** (9.5)	**13.7** (7.2)
Non-Māori	**13.8** (7.3)	**12.6** (6.7)	**4.2** (2.2)	**3.7** (1.9)

Note: Rates in bold are per 100,000 women aged 25–79 years for incidence and 25+ years for mortality, standardised to WHO world population. Rates in (parentheses) are per 100,000 females aged 0–100+, standardised to Segi population.

Table 6: Summary of key age-specific targets: total population (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	5.9	5.0	0.4	0.2
35–44	14.8	12.3	2.1	1.2
45–54	22.1	19.6	7.0	5.5
55–64	22.7	22.2	11.6	10.3
65–74	14.9	15.4	10.4	11.1
75+	3.2	2.5	12.6	11.0

Note: Rates are per 100,000 women in age group.

Table 7: Summary of key age-specific targets: Māori population (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	5.8	4.9	0.4	0.0
35–44	20.1	16.5	6.8	3.7
45–54	33.0	27.4	26.1	16.8
55–64	48.0	41.0	47.8	38.7
65–74	40.3	40.9	27.9	27.1
75+	23.4	16.8	29.6	22.4

Note: Rates are per 100,000 women in age group.

Table 8: Summary of key age-specific targets: non-Māori population (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	6.0	5.0	0.4	0.3
35–44	14.0	11.8	1.4	0.8
45–54	21.0	19.0	5.1	4.1
55–64	20.0	19.6	8.9	7.9
65–74	12.7	13.0	9.3	10.0
75+	4.1	3.3	12.1	10.6

Note: Rates are per 100,000 women in age group.

Table 9: Accepted 'headline' targets, 2006 and 2011

	2006 (2004 – 2008)	2011 (2009 – 2013)
Incidence	8.0	7.5
Mortality	2.5	2.0
Coverage (%)	75	80

Note: Incidence and mortality rates are for all cervical cancer per 100,000 females (all ages, all ethnic groups), standardised to Segi's and not hysterectomy adjusted. Coverage rates are for eligible women (ages 20 – 69 yrs, not hysterectomised).

Introduction

Mandate

In December 2002 the NCSP approached PHI for assistance in updating the Programme's outcome targets, for inclusion in the NSU Strategic Plan 2003–08.

The existing targets – for cervical cancer incidence and mortality – had been set in 1994 based on an age-period-cohort model built by Professor Brian Cox and were due to expire in 2005.

The existing targets cover all women and Māori women, and are expressed solely in terms of age-standardised rates. Until recently they have been monitored annually in the Ministry's *Progress on Health Outcome Targets* publication.

The NCSP considered it timely to commission a target resetting exercise, in view of the time elapsed since the targets were set, their rapidly approaching expiry date, and the opportunity afforded by the development of the NSU Strategic Plan 2003–08.

This report summarises the output of this exercise, including recommended incidence and mortality targets for:

- squamous as well as all cervical cancer
- non-Māori as well as Māori women
- hysterectomy-adjusted as well as unadjusted denominators
- age-specific as well as age-standardised rates and counts
- women in the age range at risk as well as females of all ages.

Targets are recommended for 2006 (actually the 2004–08 period for incidence and the 2005–09 period for mortality) and 2011 (actually the 2009–13 and 2010–14 periods for incidence and mortality respectively). If desired, targets for 2008 can be derived simply by interpolating between them.

The targets included in this report are intended to serve as a basis for consultation between the NCSP and its expert advisors and other stakeholder groups. This may appropriately lead the NCSP to further modify the suggested targets on the basis of criteria beyond the epidemiological and statistical factors considered in our modelling.

Report outline

Data sources and modelling methods are briefly outlined. We then present the recommended targets for incidence and mortality in turn. Finally some conclusions are drawn and a summary of 'key' targets presented. Details of methods are provided in Appendices 1 – 4. Appendix 5 presents a further summary of the 'key' results, expressed both as rates and as counts.

The modelling approach

In this report we recommend revised targets based on classical age-period-cohort (APC) modelling of cervical cancer incidence and mortality. Such models do not model substantive variables explicitly, but use the three time dimensions (age, period and cohort) as proxies for the 'real' drivers. In particular, in our model important programme variables such as coverage and quality are captured mainly as a period effect.

Note that we model incidence and mortality independently, even though mortality is a function of incidence and survival, as we have no time series data for survival. Hence it is possible for the incidence and mortality projections (and hence targets) to be inconsistent with each other for some age- ethnic groups in some periods.

Data sources

Periods and age groups

Unit record data from the cancer registry is used. The data is modelled in five-year age groups and five-year periods (quinary quinquennia). Incidence data is modelled from 1964–1998 and mortality from 1970-1999. All Stage Zero (or non-invasive) cancers are omitted from the dataset.

For incidence 11 five-year age groups were modelled spanning ages 25 to 79 years. There were very few cases under 25. Although data was available for age groups 80–84 and 85+ years, we omitted these age groups, as the age-specific fits in these groups were particularly poor. Omitting these age groups improved the fit of the model. (There were few incident cases at these older ages in any case.)

The two older age groups were, however, included in the mortality component of the study. There were two reasons for including these age groups: first, the mortality dataset was smaller in size than the incidence dataset and omitting the two older age groups would have made it smaller yet; second, the fit of the model was very good even with the two older age groups included.

Modelling the adeno and squamous series

The Pap smear is relatively insensitive for the detection of adenocarcinoma of the cervix or its precursors. So the objectives of the NCSP are couched in terms of the prevention of squamous cancer (Ministry of Health 1996), and the targets should arguably be set for this morphological type of cancer only.

Reliable morphology data is available only from 1978. Due to the poor quality of morphology data prior to 1978, squamous and adeno cancers were modelled for these earlier periods.

Prior to 1979, the incidence rate for adeno cancers is modelled by averaging adeno incidence rates from 1979 to 1998 (Figure 1). The age- and period-specific adeno rates are relatively stable over this period, and we believe that this smoothed rate is an adequate proxy. Mortality rate for adeno cancers is modelled by averaging the adeno mortality rate from 1980 to 1999 (Figure 2).

Adeno cases are then derived by multiplying by the person-years denominator. Note that we have modelled adeno cases using both hysterectomy-adjusted and unadjusted denominators. Both denominators yielded near identical results, with discrepancies of one case at most in a couple of the cells. For the final analysis we have used the hysterectomy-adjusted results.

The squamous series is calculated by subtracting the adeno cases (modelled prior to 1979/80 and observed thereafter) from the 'all cervical cancers' series. Note that included in the squamous category are adeno-squamous carcinomas and also those cancers that could not be coded due to ambiguity in morphology. Due to the poor quality of data available on these 'other' cancers we were unable to model these separately and so derive a 'pure' squamous series. These 'other' cancers, however, are few in number, and therefore, we do not envisage a problem including them in the squamous series.

Figure 1: Smoothed adenocarcinoma incidence rates, 1979–98

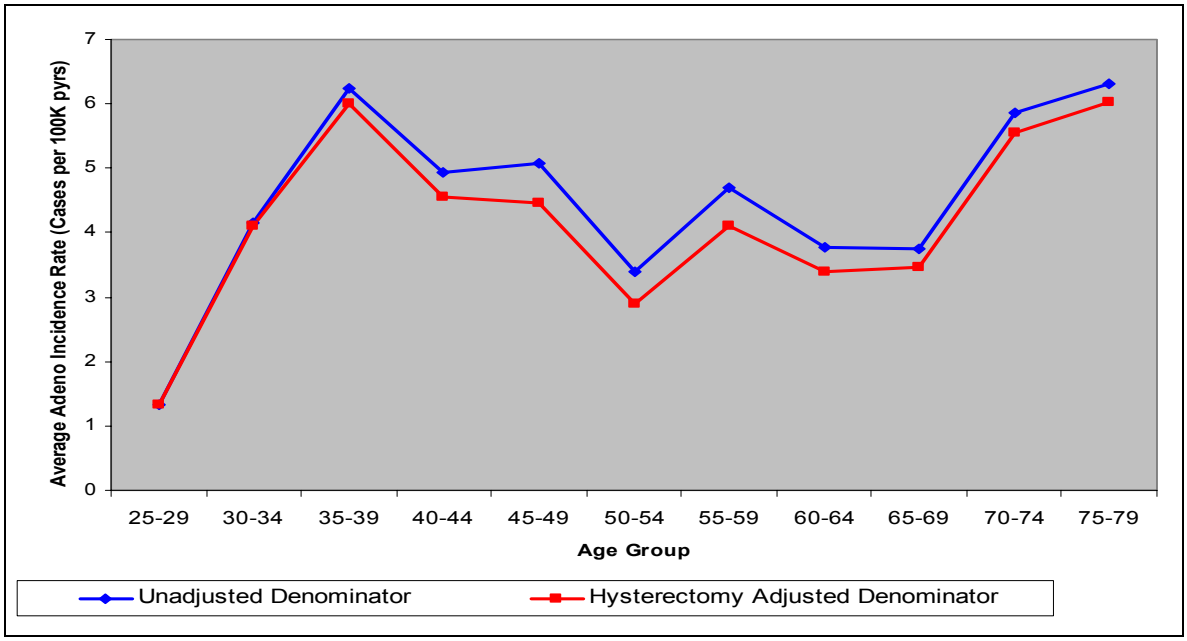
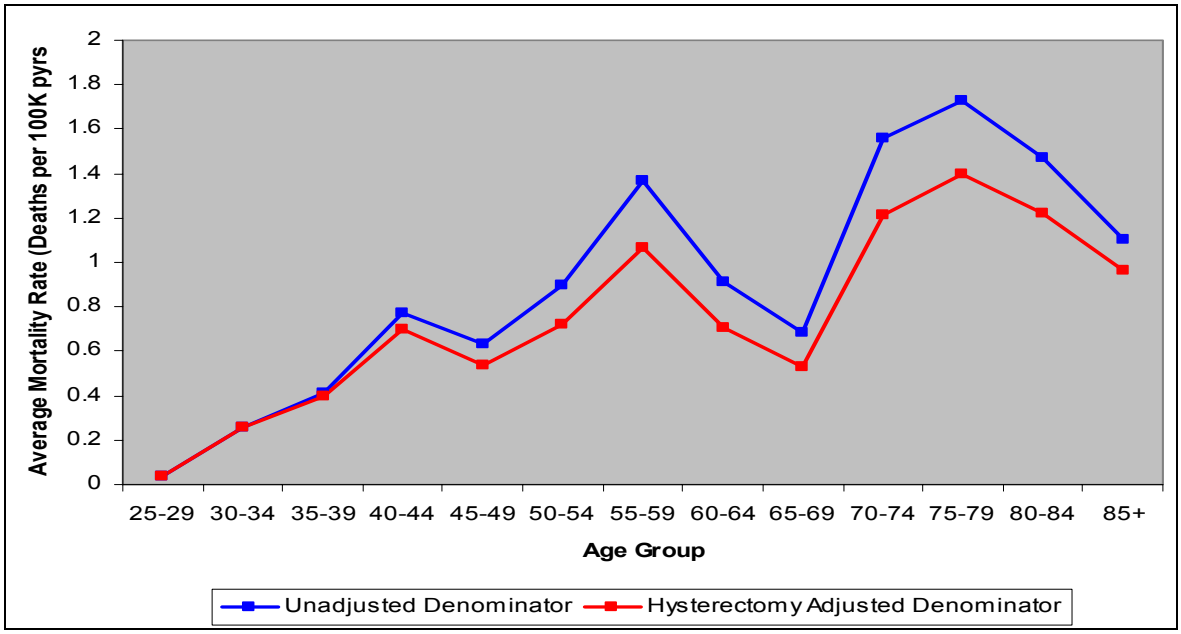


Figure 2: Smoothed adenocarcinoma mortality rates, 1980–99



Population estimates

Mid-year population estimates between 1964 and 2001, and projections based on the 1996 census for the years 2002 to 2014, were obtained from Statistics New Zealand (SNZ). Māori population projections were based on the 2001 census population. Two denominators were used to derive incidence and mortality rates:

1. all female person-years in the age groups modelled; and
2. hysterectomy-adjusted female person-years in the age groups modelled.

When deriving incidence and mortality rates, the denominator should, ideally, reflect the population at risk. It is therefore preferable to exclude those women who have had a hysterectomy and hence are no longer at risk of cervical cancer.[5] On the other hand, adjusting for hysterectomy prevalence creates an additional source of uncertainty, as historical hysterectomy rates are not well documented and must in any case be projected into the future. For this reason, both hysterectomy-adjusted and unadjusted rates are presented in this report.

The hysterectomy-adjusted population was estimated by modelling hysterectomy prevalence in New Zealand women between 1964 and 1999. Hysterectomy-adjusted population projections were based on the 2001 census population.

We determined New Zealand hysterectomy procedure incidence by extracting public and private hospital discharges[6] for any patient who had an ICD-9 code in

[5] Except for the small proportion of women – less than 10% – for whom the hysterectomy formed part of the treatment for cervical cancer.

[6] Data provided by NZHIS.

the range 683-687, 689. For public hospitals we had discharges from 1978–2002[7] and for private hospitals we had discharges from 1980–1995. We also extracted age in years at discharge and year of discharge.

To estimate the periods 1978–1979 and 1996–2002 for private hospital hysterectomy procedure discharges, we extrapolated the trend for the total discharges for these years based on the existing private data for the closest five years and then allocated proportionately to five-year age categories based on the distribution of these closest years.

For remoter historical periods, we assumed no incidence of hysterectomy prior to 1900, a gradual increase until 1941 to about 10 percent of the current incidence, and then a linear increase until 1956, to the levels provided by historical hysterectomy data.

We then used central estimates of survival and hysterectomy incidence by five-year age groups and five-year periods to generate a life table of survival of women having had a hysterectomy to determine the prevalence of hysterectomy in any given age group and period.

Modelled hysterectomy prevalence estimates are summarised in Appendix 3.

[7] 2002 discharges for January to June.

Methods

Classical age-period-cohort (APC) models were used to analyse incidence and mortality data. Hodgen (2003) provides a detailed summary and comparison of the various methods available to analyse cancer incidence and mortality, including the classical APC approach, as well as Bayesian and non-parametric approaches.

A brief description of the classical APC model is provided below.

The classical APC model

The classical APC approach is an empirically based general model that holds that the ratios of age-specific rates between two groups of individuals with different exposures to carcinogenic influences are constant for all age groups (Clayton and Schifflers 1987).

The mean number of cases, μ_{ap} in each age group in each period is modelled as being the product of age, period and cohort effects. Under the assumption that the number of cases in each age group in each period is approximately Poisson with mean $R_{ap}n_{ap}$, where R_{ap} is the risk of cancer in the group, and n_{ap} is the number of person-years (population) at risk, the appropriate model to fit is a generalised linear model with a log link function, with the number of person-years modelled as an offset:

$$y_{ap} \sim \text{Poisson}(\mu_{ap})$$
$$\log(\mu_{ap}) = \alpha_a + \pi_p + \gamma_c + \log(n_{ap})$$

where α_a is the age parameter in the a-th age group (a = 1, 2, ..., A), π_p is the period parameter in the p-th period (p = 1, 2, ..., P) and γ_c is the c-th cohort parameter (c = 1, 2, ..., C, where c = A + p – a and C = A + P – 1).

A well-known problem with APC models is non-identifiability. Given an age group and a period, we automatically know what the associated birth cohort is. More generally, given any two of the age, period and cohort indices, the third one is determined.

Furthermore, the fitted values are actually identifiable, meaning that completely different sets of effect estimates will give us the same set of fitted values. The problem then becomes one of choosing that set of effects which is most prudent, both intuitively and epidemiologically.

For the purposes of this study, and to ensure that we were obtaining prudent age, period and cohort effects, two methods were employed to derive alternative estimates for age, period and cohort effects: methods suggested by Holford (1991) and by Osmond and Gardner (1982).

We found that the age, period and cohort effects obtained using these methods were, in fact, very similar to each other and to the estimates obtained using the statistical language R. R uses 'treatment contrasts' (by default) when fitting generalised linear models. The last period effect is set to zero, and the first and last cohort effects are set to zero (corner point constraints). The projections reported here use the estimates obtained using R.

In any case, it should be noted that projections are largely unaffected by the non-identifiability problem (Osmond 1985).

Scenarios modelled

Multiple scenarios were modelled to assess the effectiveness of the screening programme and eventually set the targets. These scenarios are briefly described below.

The 'optimal' scenario

Under this scenario, we assume current trends will continue into the future. In other words the classical APC model is applied to the existing data, and incidence and mortality rates are forecasted by projecting period and cohort effects using simple linear regression on the last three periods and birth cohorts (Osmond 1985). That is:

$$\hat{\pi}_p = \beta_{0p} + \beta_{1p} p$$
$$\hat{\gamma}_c = \beta_{0c} + \beta_{1c} c,$$

for p>P and c>C.

The drawback of this method is that it assumes current trends will continue into the future. The projected incidence and mortality rates obtained under this scenario are therefore highly optimistic, and somewhat unrealistic (especially for non-Māori women) since they assume no saturation of programme coverage.

This was the scenario modelled in *Cancer in New Zealand: Trends and Projections* (Ministry of Health 2002b) for consistency with other cancer sites.

Note that we use this drawback to our advantage when modelling the counterfactual scenario (see below).

The 'business as usual' scenario

The 'business as usual' (BAU) scenario assumes that no additional intervention measures are implemented, over and above what is already in place (ie, programme coverage and quality are held stable at current levels).

This is modelled by assuming that period effects stabilise (or remain at the same level) after the last modelled period. Cohort effects are still modelled using linear regression on the last three birth cohorts. That is:

$$\hat{\pi}_P = \hat{\pi}_{P+1} = \hat{\pi}_{P+2} = \ldots = \hat{\pi}_{P+j}$$

$$\hat{\gamma}_c = \beta_{0c} + \beta_{1c} c,$$

for c>C, and j is the additional number of periods we require projections for.

The 'target' scenario

The 'target' scenario is used to actually set the incidence and mortality targets. Projected period effects are assumed to track halfway between those of the optimal and BAU scenarios (that is, challenging but achievable improvements in programme coverage and quality over the next few years are assumed). Cohort effects are projected as before:

$$\hat{\pi}_{p,target} = \frac{\hat{\pi}_{p,optimal} + \hat{\pi}_{p,BAU}}{2}$$

$$\hat{\gamma}_c = \beta_{0c} + \beta_{1c} c,$$

Note that the target incidence rates correspond to the periods 2004–2008 and 2009–2013. However, for policy purposes they can be considered to be targets to be achieved by 31 December 2006 and 31 December 2011 respectively.

Similarly, for mortality, targets are derived for the 2005–2009 and 2010–2014 periods, but can also be considered to be targets to be achieved by 31 December 2006 and 31 December 2011 respectively (instead of 2007 and 2012), with relatively little inaccuracy being introduced by so doing.

Targets for 2008 can be derived, if desired, by interpolating between the 2006 and 2011 targets (examination of the model supports the assumption of linearity). That is, it would be reasonable to set a target for 31 December 2008 midway between the '2006' and '2011' targets.

The 'counterfactual' scenario

This is the 'worst-case' scenario, where we model what would have happened in the absence of the screening programme.

This scenario is modelled by applying the APC model to a reduced dataset. Specifically, the last period modelled precedes the period when the screening programme commenced (approximately 1991). For incidence the last period modelled is 1984–1988 while for mortality it is 1985–1989. In other words, rather than modelling the 1990's we project period and cohort effects using linear regression. Because this assumes that the historical trends of the 1960s–1980s will continue into the 1990s, rates projected under this scenario provide an indication of what would have happened had there been no screening programme.

Setting ethnic specific targets

Due to the poor quality of Māori data as well as varying ethnicity definitions over the modelled periods, Māori women are not modelled separately. Instead, Māori rates are modelled by examining the ratio of Māori[8] to total cervical cancer cases and deaths over the 1991 to 1999 period and averaging the observed Māori proportions. These estimated proportions are then applied to the projected numbers of cervical cancer cases (or deaths) in the total population (using the APC approach) to obtain an estimate of the number of Māori specific cervical cancer cases (or deaths), which in turn are used to derive the targets.

Data for non-Māori were modelled in the same way, using one minus the proportion Māori.

More detail on modelling of ethnic specific data is provided in Appendix 4.

Screening impact: number of cases and deaths averted due to screening (formal and informal)

The number of incident cases and deaths averted due to screening are estimated by comparing the target and counterfactual scenarios. The number of estimated cases is derived by multiplying fitted incidence/mortality rates by the appropriate person-years denominator:

$$\hat{cases}_{ap} = \hat{R}_{ap} \times n_{ap}.$$

The number of cases/deaths averted is given by the difference between the estimated number of cases under the target scenario and the counterfactual (worst case) scenario:

$$\Delta\hat{cases}_{ap} = \hat{cases}_{ap\,(counterfactual)} - \hat{cases}_{ap\,(target)}.$$

[8] Māori cases and deaths are first adjusted for the estimated degree of undercounting of Māori ethnicity in cancer registrations and mortality records. This is done by record linkage, to hospitalisations in the former and census data in the latter case (ie, the mortality adjusters are derived from the New Zealand Census – Mortality Study (Ajwani et al 2002)).

Results

Incidence

Figures 3–6 show the projected age-standardised incidence rates for all cervical cancers and for squamous cancers under the different scenarios (age-specific results are not shown because of space limitations).

The year on the x-axis denotes the midpoint of the respective five-year period. So, for example, 1966 denotes the 1964–1968 period, and so on.

Also note that the graphs show only all New Zealand results. Ethnic-specific results are discussed in later sections.

Note that WHO weights are used in the graphs below, and in the summary table. We found that standardising rates with Segi and WHO weights yielded almost identical results.

The recommended age-standardised targets appear very different from the existing targets. This is because the existing targets are expressed per 100,000 females of all ages (0–100+), whereas the recommended targets are restricted to the age range considered to be at risk, namely 25–79 years. To facilitate comparison with the existing targets, and with rates published internationally, we also show the recommended targets expressed per 100,000 females of all ages (0–100+) and standardised to Segi's rather than the WHO world population (these latter rates are shown in parentheses).

Including all graphs of modelled age, period and cohort effects would prove unwieldy. To this end, graphs of the estimated age, period and cohort effects under all scenarios are presented in Appendix 1.

Figure 3: Age-standardised incidence rates for all cervical cancers (denominator unadjusted), 1966–(projected) 2001

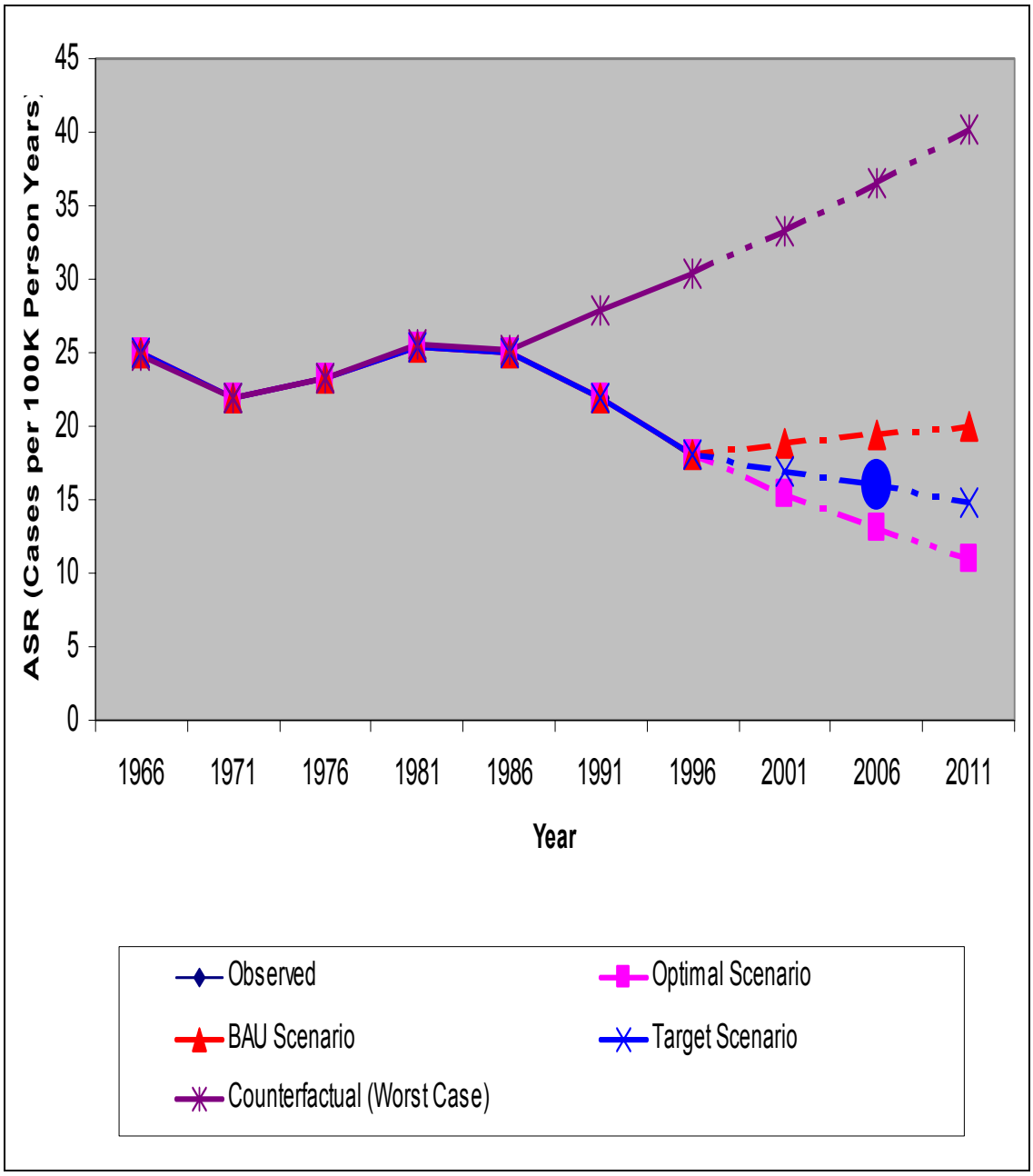


Figure 4: Age-standardised incidence rates for all cervical cancers (denominator hysterectomy-adjusted), 1966–(projected) 2011

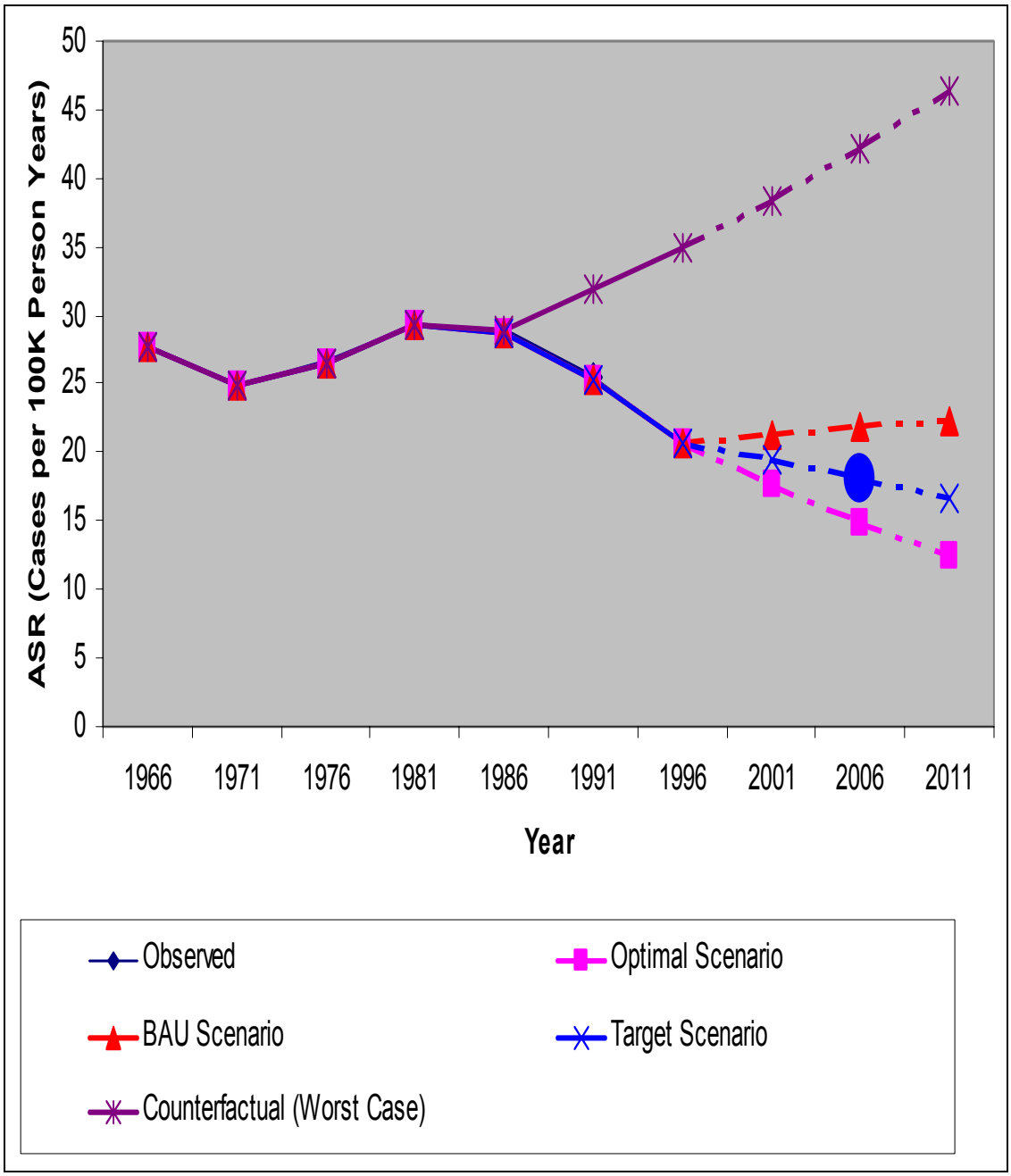


Figure 5: Age-standardised incidence rates for squamous cervical cancers (denominator unadjusted), 1966–(projected) 2011

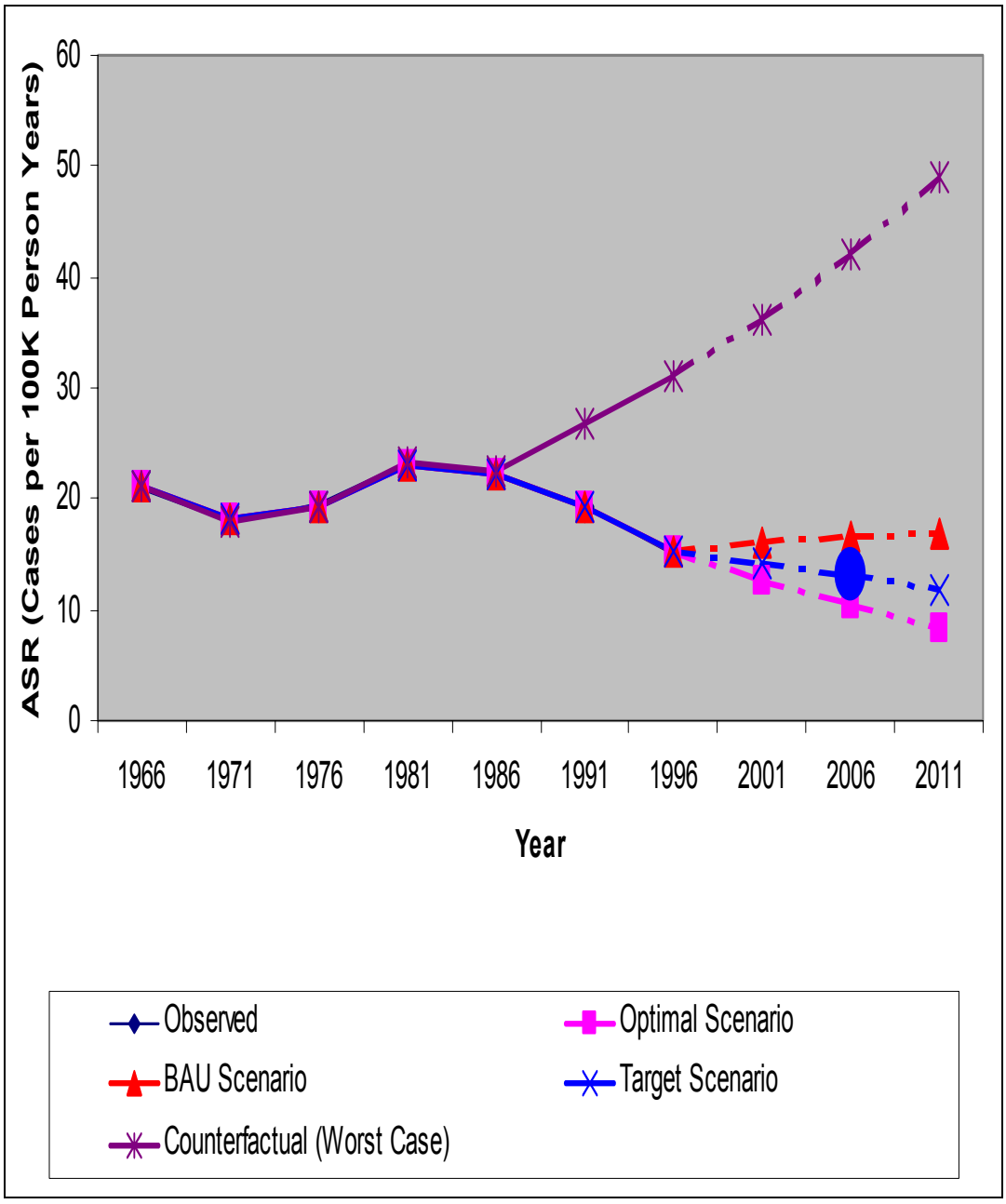
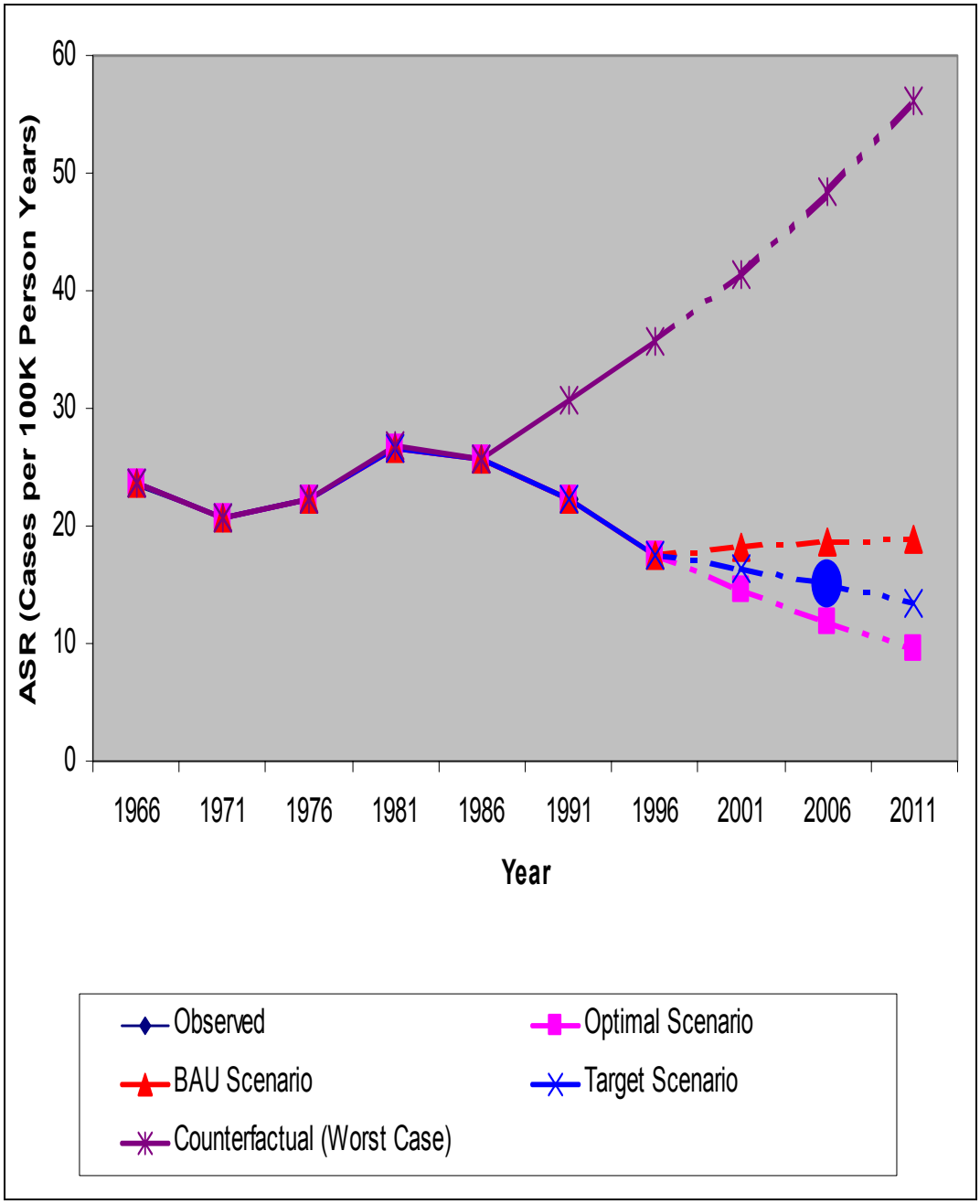


Figure 6: Age-standardised incidence rates for squamous cervical cancers (denominator hysterectomy-adjusted), 1966–(projected) 2011



The basic trend of age-standardised incidence rates over time (under all scenarios) is consistent, whether we are modelling all cervical cancers or squamous cervical cancers only.

Of particular interest are the counterfactual and BAU scenarios. Under the counterfactual scenario, the ASR steadily increases. The rate of this increase is, in fact, greater for squamous cancer. This is evident in Figures 5 and 6: from the 1984–88 period onward, the ASR for squamous cancers increases at a steeper rate than does that for all cervical cancers.

The BAU scenario indicates that if the screening programme were to continue at current levels of performance (in terms of coverage and quality), then the ASR would *increase* over time as well, albeit much more slowly than under the counterfactual scenario.

Age-standardised incidence targets

Figures 7–9 summarise the age-standardised incidence rates projected under the target scenario. Note that, as expected, when the denominator is adjusted to reflect the hysterectomy-adjusted population, the targets are slightly higher (than when the denominator is unadjusted), because the population at risk is now smaller.

Figure 7: Age-standardised incidence targets: all New Zealand women

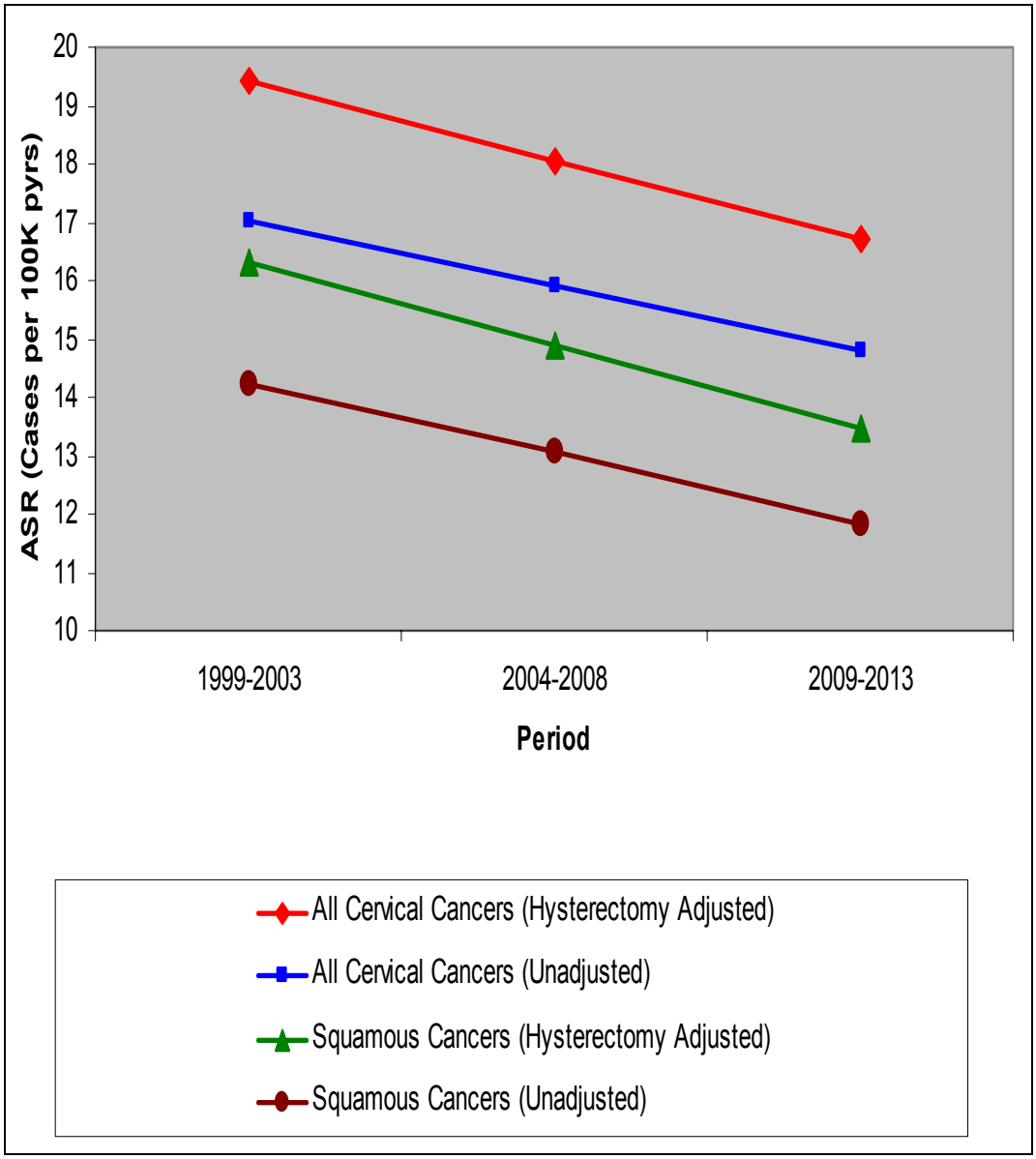


Figure 8: Age-standardised incidence targets: Māori women

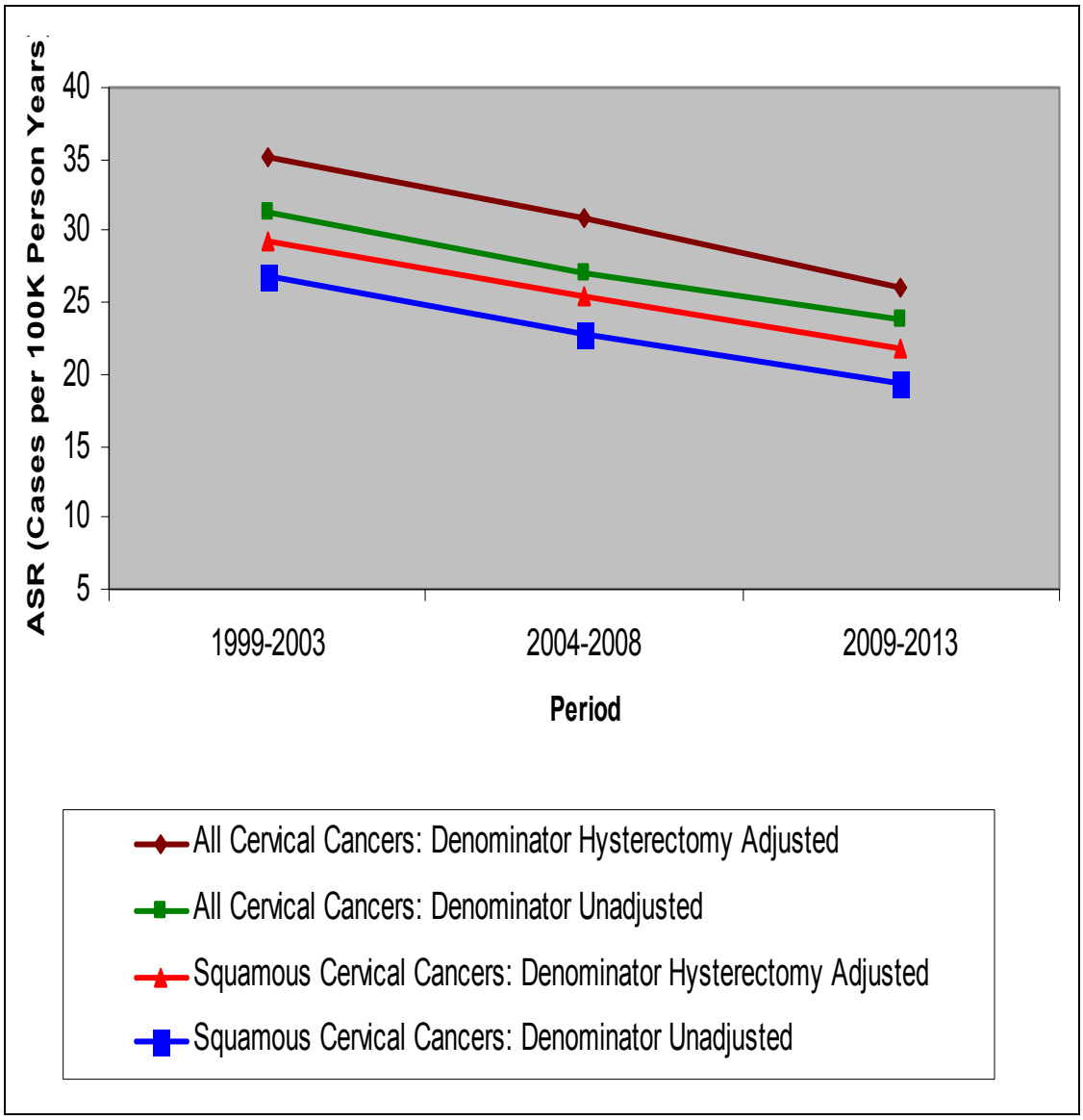


Figure 9: Age-standardised incidence targets: non-Māori women

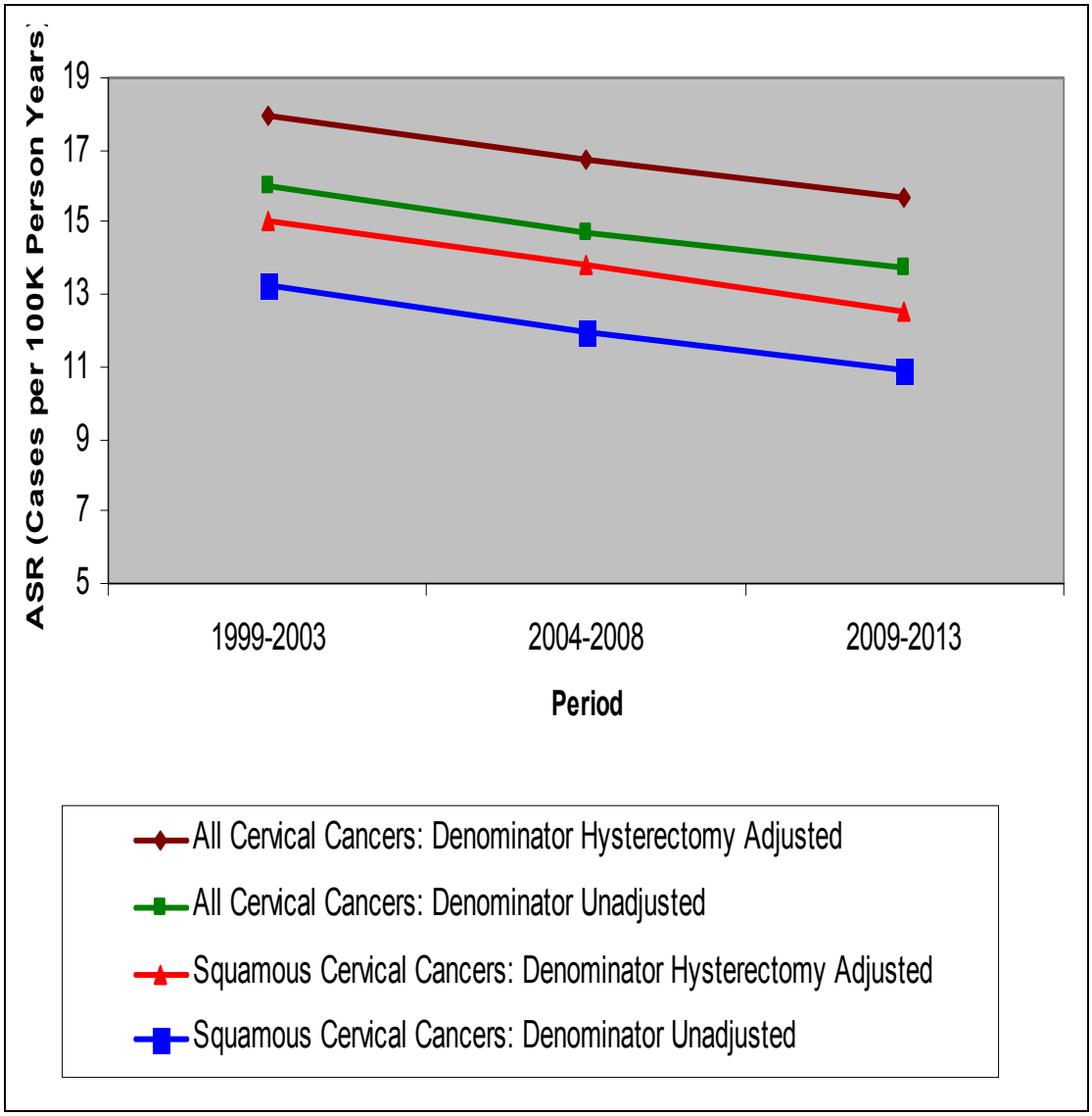


Table 9 summarises the recommended age-standardised incidence targets (in bold). Rates standardised in accord with NSU convention (ie, standardised to a 0–100+ Segi population) are provided in parentheses.

Table 10: Recommended age-standardised incidence targets

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	**Unadjusted population**	**Hysterectomy-adjusted population**	**Unadjusted population**
Total population				
2006 Incidence	**18.1** (9.6)	**15.9** (8.4)	**14.9** (7.9)	**13.1** (6.9)
2011 Incidence	**16.7** (8.8)	**14.8** (7.8)	**13.5** (7.1)	**11.8** (6.3)
Māori population				
2006 Incidence	**31.0** (16.4)	**27.1** (14.3)	**25.5** (13.5)	**22.9** (12.1)
2011 Incidence	**26.1** (13.8)	**23.8** (12.6)	**21.8** (11.5)	**19.4** (10.3)
Non-Māori population				
2006 Incidence	**16.7** (8.9)	**14.7** (7.8)	**13.8** (7.3)	**12.0** (6.3)
2011 Incidence	**15.7** (8.3)	**13.7** (7.3)	**12.6** (6.7)	**10.9** (5.6)

Note: Rates in bold are per 100 000 women (25-79 years), standardised to WHO world population; Rates in parentheses are are 100 000 females (0-100+ years), standardised to Segi's population.

Age-specific incidence targets

Figures 10–15 show recommended age-specific targets by 10-year age groups for periods 2004–2008 (target for 2006) and 2009–2013 (target for 2011).

Figure 10: Age-specific incidence targets: total population (2004–08)

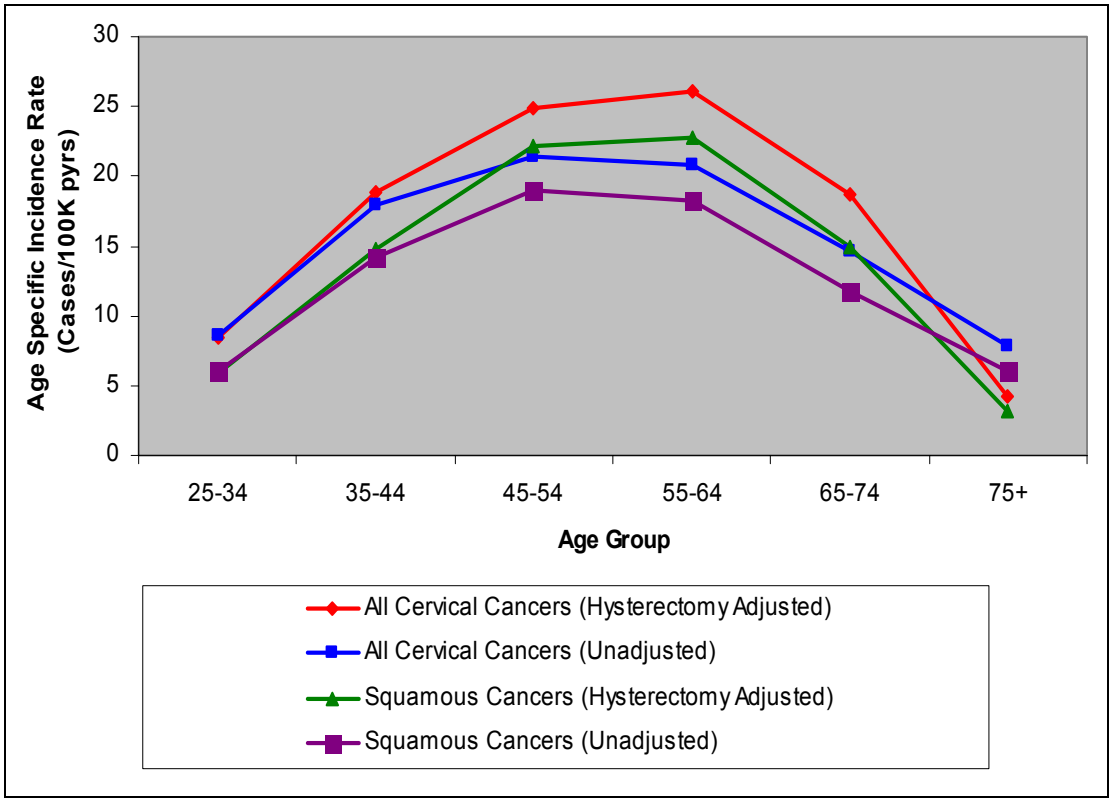


Figure 11: Age-specific incidence targets: total population (2009–13)

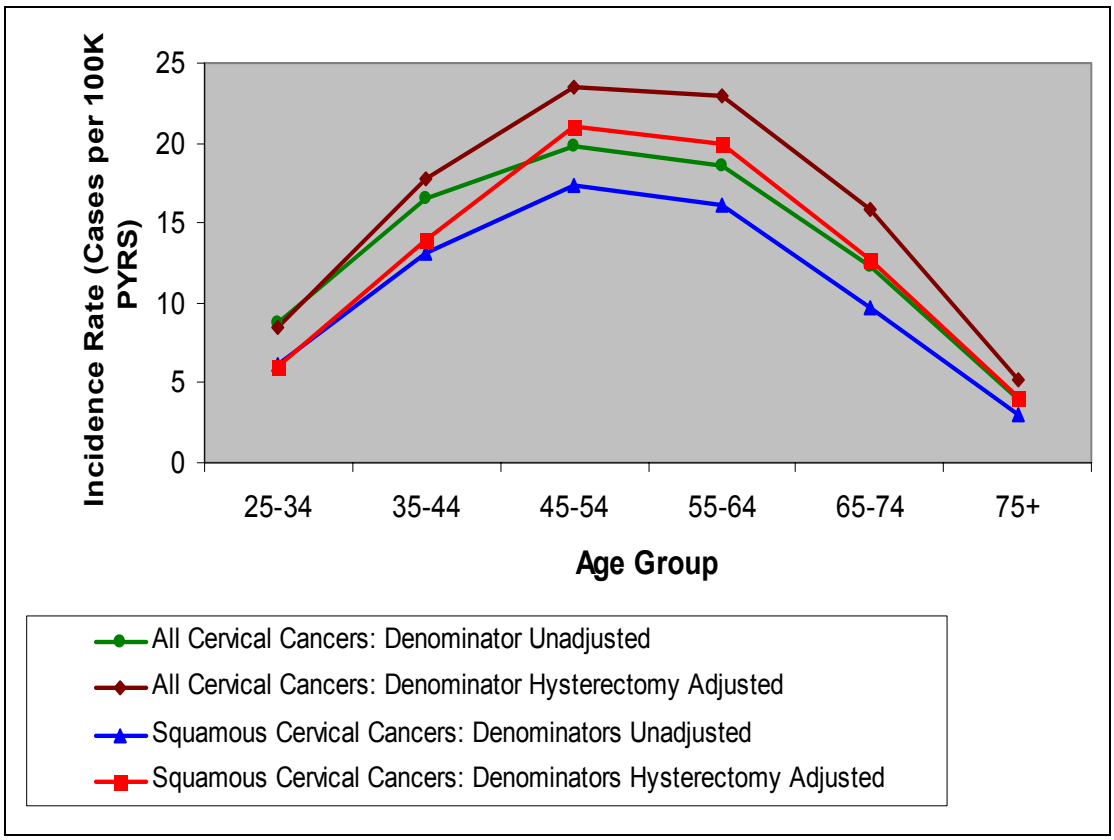


Figure 12: Age-specific incidence targets: Māori population (2004–08)

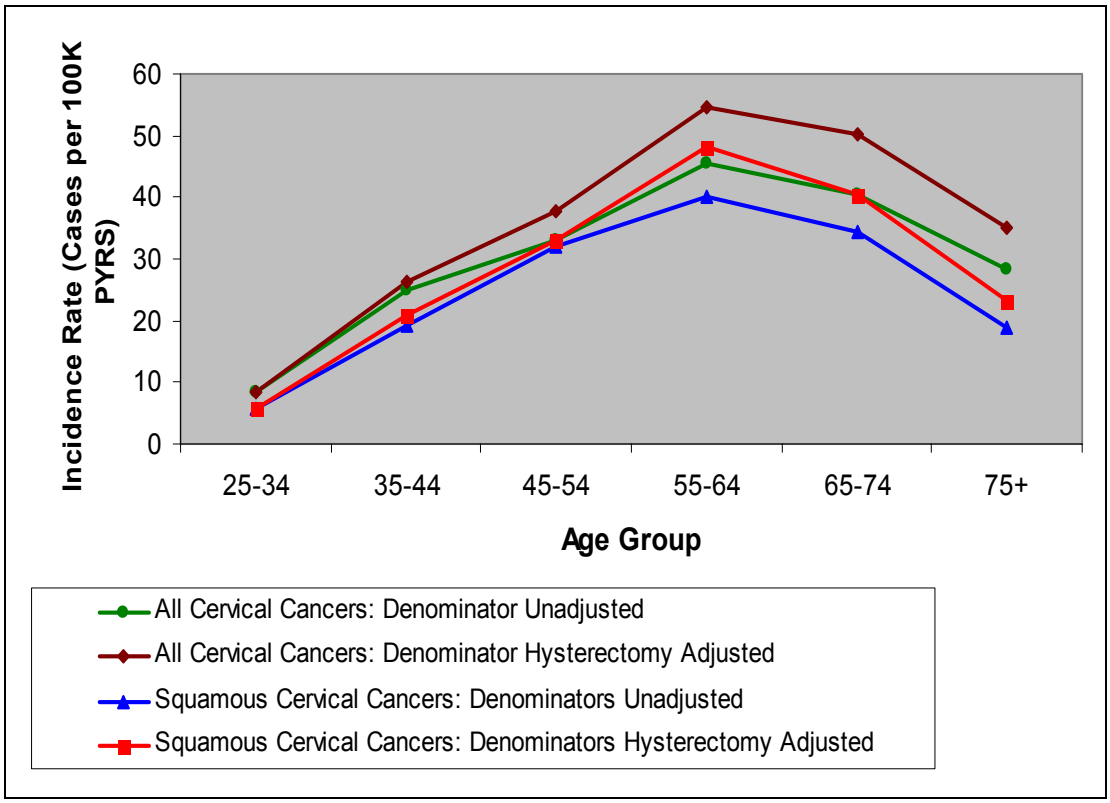


Figure 13: Age-specific incidence targets: Māori population (2009–13)

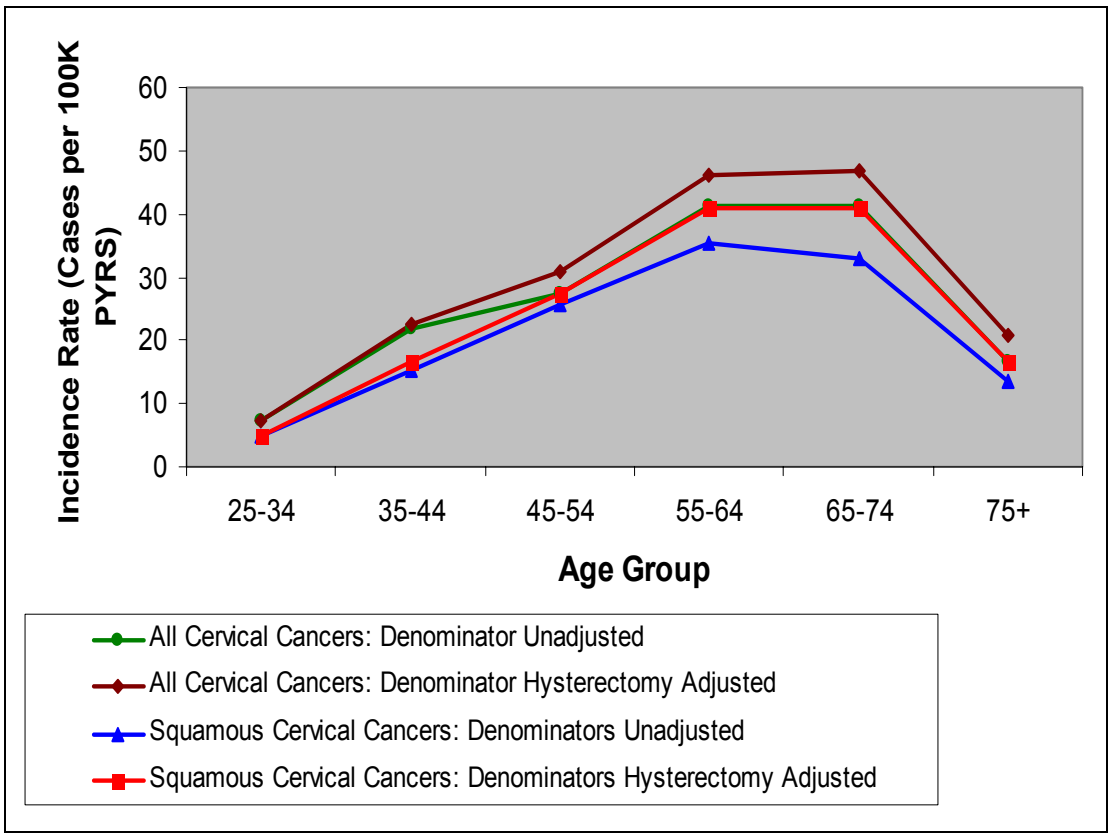


Figure 14: Age-specific incidence targets: non-Māori population (2004–08)

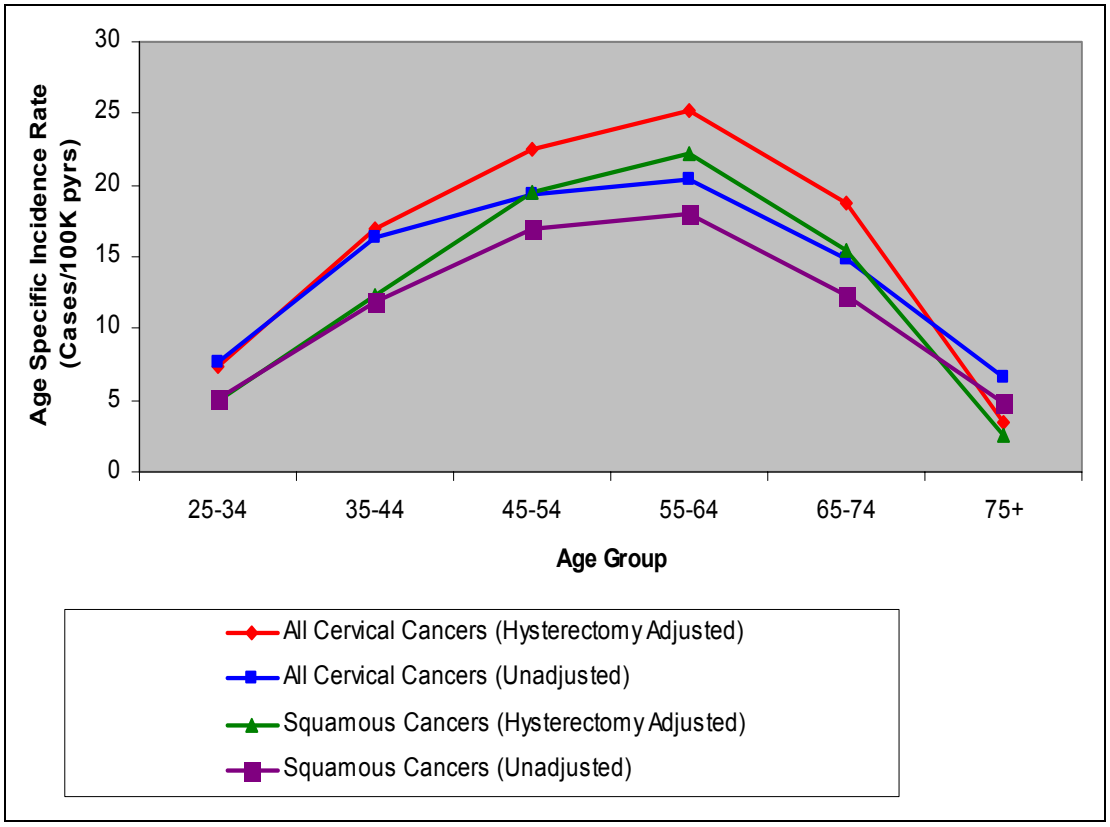
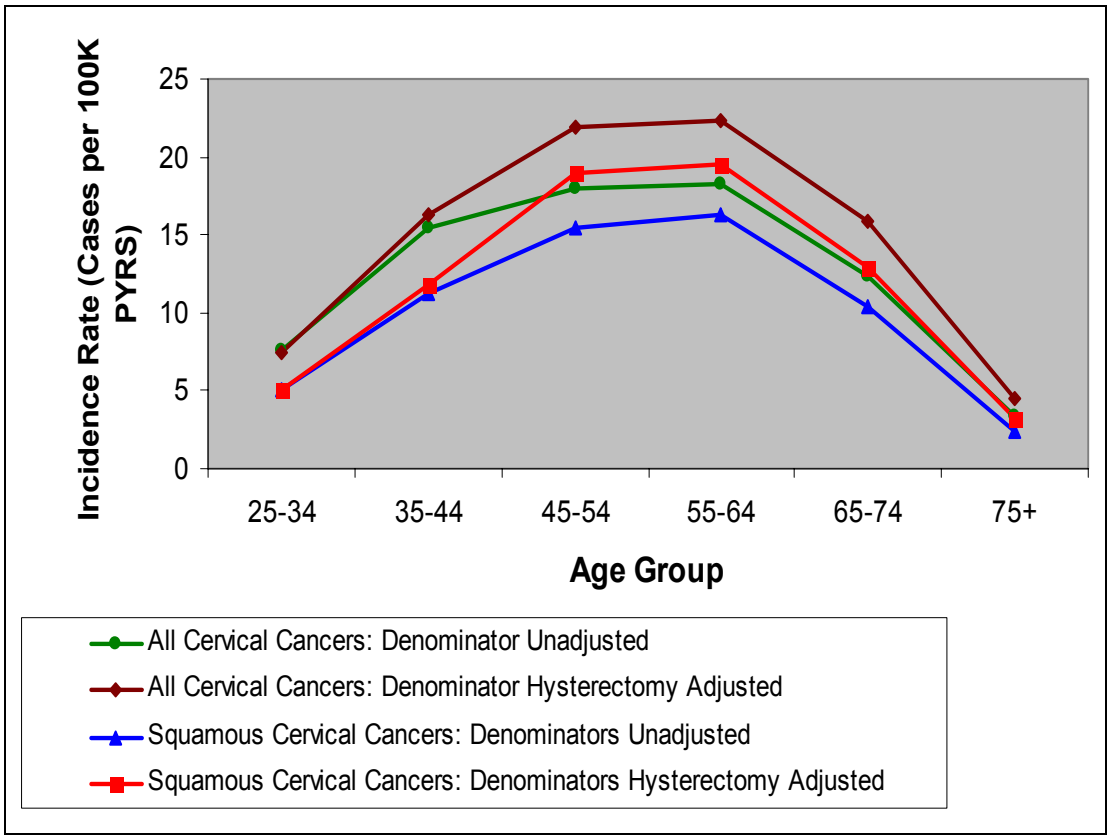


Figure 15: Age-specific incidence targets: non-Māori population (2009–13)



Tables 11 and 12 summarise the age-specific incidence rate targets for the 2004–08 and 2009–13 periods respectively.

Table 11: Age-specific incidence targets, 2004–08

Age group (years)	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
Total population				
25–34	8.4	8.6	5.9	6.0
35–44	18.8	18.0	14.8	14.1
45–54	24.8	21.4	22.1	19.0
55–64	26.1	20.8	22.7	18.2
65–74	18.7	14.7	14.9	11.8
75–79	4.3	4.8	3.2	3.6
Māori population				
25–34	8.4	8.4	5.8	5.8
35–44	26.3	25.0	20.1	19.1
45–54	37.7	33.2	33.0	32.0
55–64	54.8	45.6	48.0	40.0
65–74	50.4	40.3	40.3	34.3
75–79	35.1	28.3	23.4	18.9
Non-Māori population				
25–34	8.4	8.8	6.0	6.2
35–44	17.8	16.6	14.0	13.1
45–54	23.5	19.9	21.0	17.4
55–64	22.9	18.5	20.0	16.2
65–74	15.9	12.3	12.7	9.7
75–79	5.2	3.9	4.1	3.0

Note: Rates are per 100 000 in age group

Table 12: Age-specific incidence targets, 2009–13

Age group (years)	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
Total population				
25–34	7.3	7.6	5.0	5.1
35–44	16.9	16.3	12.3	11.8
45–54	22.5	19.4	19.6	16.9
55–64	25.2	20.4	22.2	18.0
65–74	18.7	14.8	15.4	12.3
75–79	3.5	6.6	2.5	4.8
Māori population				
25–34	7.2	7.1	4.9	4.9
35–44	22.5	21.7	16.5	15.4
45–54	30.7	27.3	27.4	25.8
55–64	46.0	41.3	41.0	35.3
65–74	47.0	41.2	40.9	33.0
75–79	21.0	16.8	16.8	13.5
Non-Māori population				
25–34	7.4	7.6	5.0	5.0
35–44	16.3	15.4	11.8	11.2
45–54	22.0	18.0	19.0	15.4
55–64	22.3	18.3	19.6	16.3
65–74	15.9	12.3	13.0	10.4
75–79	4.6	3.4	3.3	2.4

Note: Rates are per 100 000 in age group

Although only age-standardised targets were requested, we feel that setting age-specific targets is more prudent. As the above tables indicate, the age-specific incidence rates vary considerably over the different age groups. Furthermore, examining the behaviour of age-specific incidence rates over time indicates that the trends over different age groups are by no means consistent (reflecting cohort effects).

Also note that in the youngest 10-year age group (25–34 year olds) Māori women actually have lower age-specific incidence rates than their non-Māori counterparts (although this difference may not be statistically significant). The gap between Māori and non-Māori is particularly large for middle-aged women. Such information is lost when examining only age-standardised rates.

Comparison with existing targets

The existing targets (which are age-standardised rates for 2005) can be compared with the recommended all cervical cancer non-hysterectomy-adjusted targets for 2006 for all women and for Māori women (with rates expressed per 100,000 females of all ages standardised to Segi's reference population).

Table 13: Comparison of existing and recommended incidence targets

	All women	Māori women
Existing target	8.6	11.0
Recommended target	8.4	14.3

Note: Rates are per 100 000 females (0 – 100 + years), standardised to Segi's population

The recommended target for all New Zealand women (when expressed in similar terms) is very close indeed to the existing target. However, the recommended target for Māori women is about 30 percent higher than the existing target. This may reflect in part our correction for the undercounting of Māori cancer registrations.

Estimating screening impact

Figures 16 and 17 illustrate the number of incident cases and cumulative cases (respectively) that have been averted due to screening. The number of cases averted is obtained by comparing the actual number of observed cases to the estimated number of cases under the counterfactual scenario. We were unable to obtain cancer registrations for the 1999–2003 period, so the number of estimated cases averted during this period is based on projections under the target scenario.

Table 14 summarises the estimated number of incident cases averted due to screening to date. Note that this estimate includes informal as well as formal screening, and also assumes that screening is the sole cause of the period effect.

Note that there is a discrepancy between the number of cases averted when the denominator is adjusted to reflect the hysterectomy-adjusted population. This is because the number of cases is derived by multiplying the incidence rate by the appropriate population denominator (which is different for hysterectomy-adjusted populations).

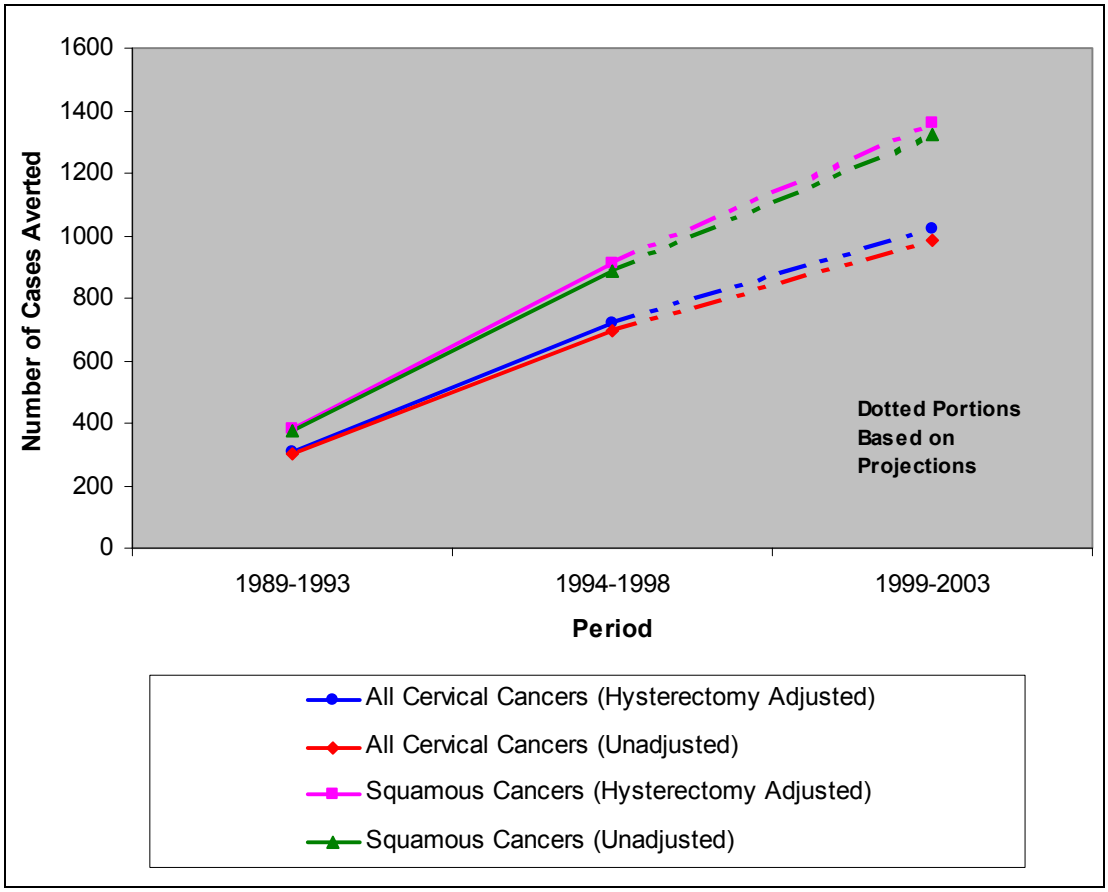
Also, in theory, the number of all cervical cancer cases averted must be greater than or equal to the number of squamous cases averted. However, this is not the case in Table 14. The reason is that the squamous and all cervical cancers series are modelled separately, and yield different rates, and hence a different number of estimated cases. The number of squamous cases and deaths is therefore, not dependent upon the number of all cervical cancer cases and deaths (in our model).

Table 14: Number of incident cases averted due to screening

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
1989–93	305	300	381	377
1994–98	717	693	912	887
1999-2003[9]	*1022*	*985*	*1360*	*1323*

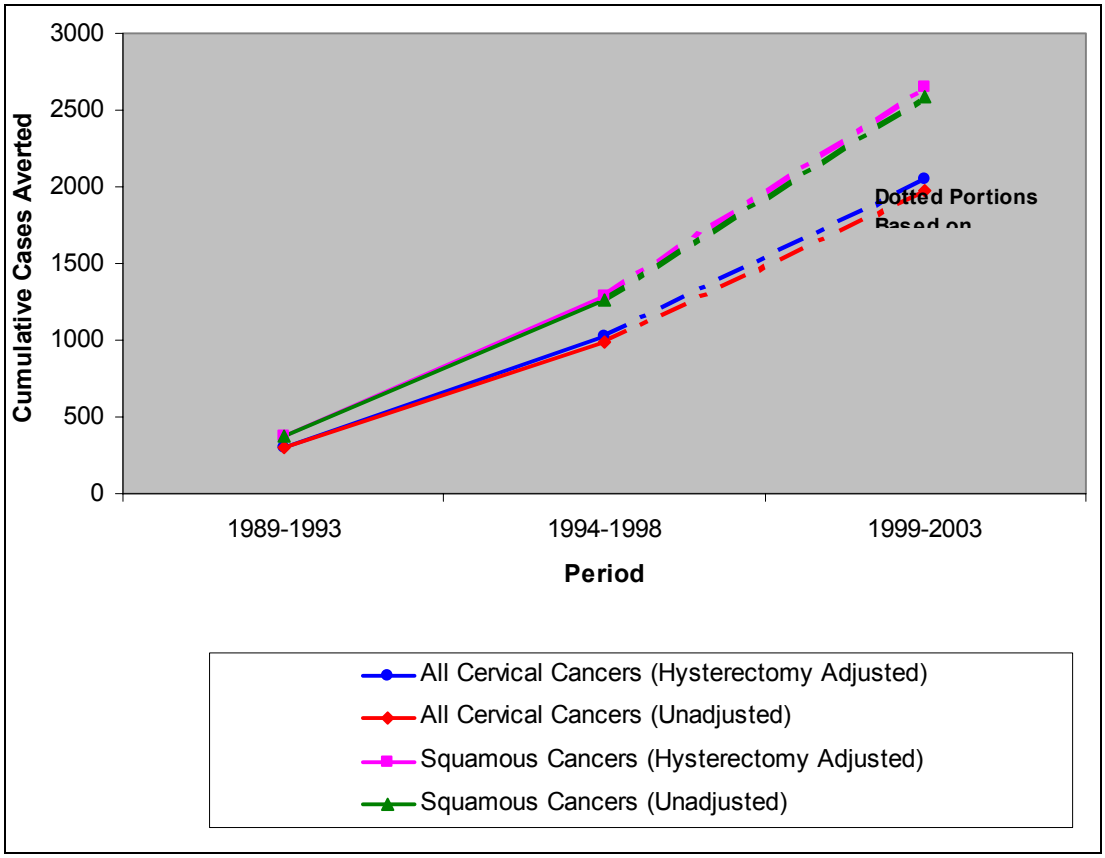
From Table 14 we estimate the cumulative number of squamous cervical cancer cases prevented by screening (whether performed as part of the NCSP or not) since 1990–91 until the end of 2003 to be approximately 2650 cases (but it could be as low as 1980 cases if the 'all cervical cancer non-hysterectomy-adjusted' series is used).

Figure 16: Estimated number of incident cases of cervical cancer averted in each period due to screening



[9] Based on projections.

Figure 17: Estimated cumulative number of incident cases of cervical cancer averted due to screening



Mortality

Age-standardised mortality rates modelled under the various scenarios are provided in this section. As before, for the sake of brevity, plots of modelled age, period and cohort effects are not shown here, but are instead included in Appendix 2.

Plots of age-standardised mortality rates are per 100,000 women aged 25–100+, and use WHO weights.

Results pertaining to the total population are presented in this section, while ethnic specific results are presented in following sections.

Figures 18–21 show the projected age-standardised mortality rates for all cervical cancers and for squamous cancers under the different scenarios.

Figure 18: Age-standardised mortality rates for all cervical cancers (denominator unadjusted), 1972–2012

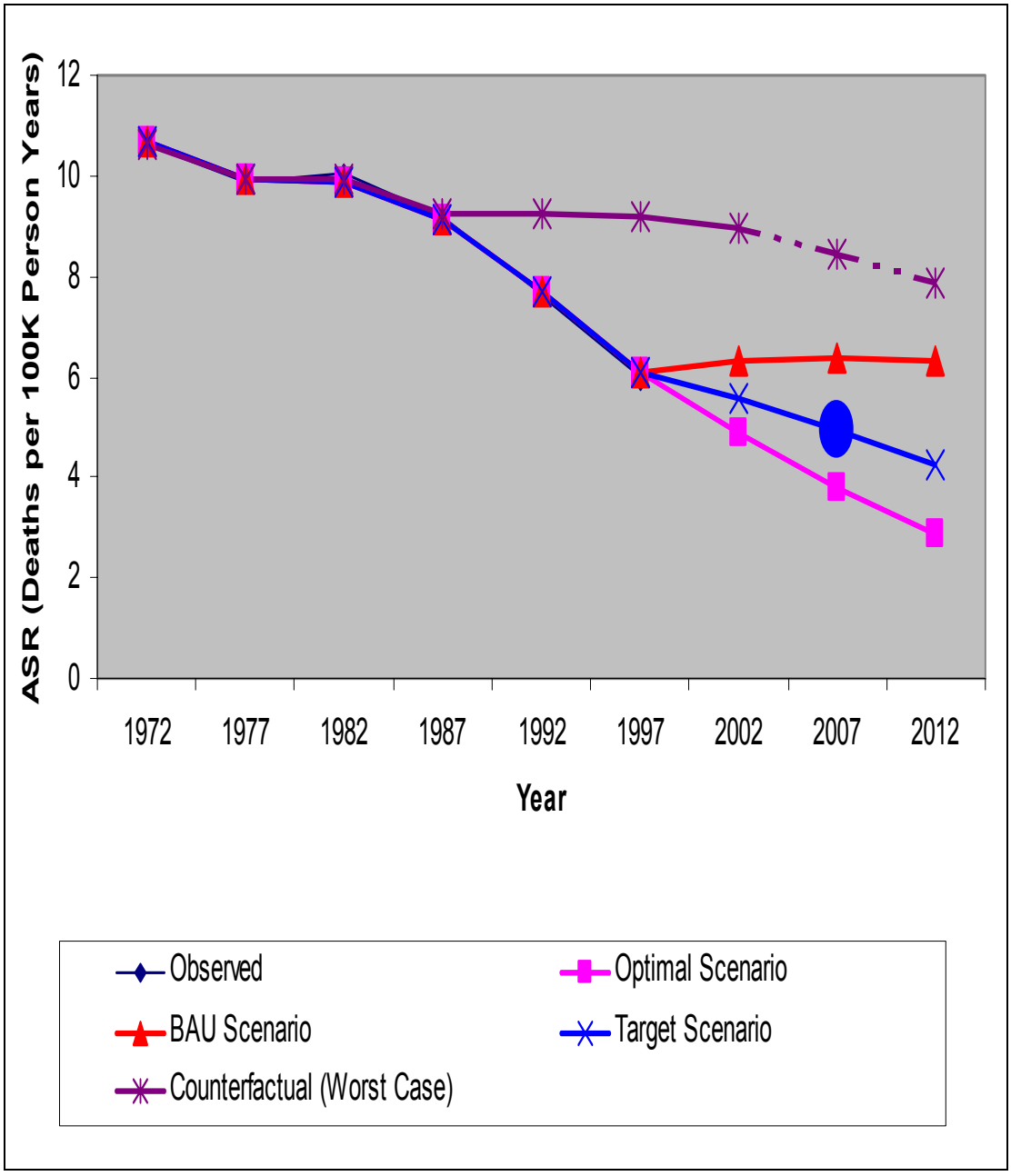


Figure 19: Age-standardised mortality rates for all cervical cancers (denominator hysterectomy-adjusted), 1972–2012

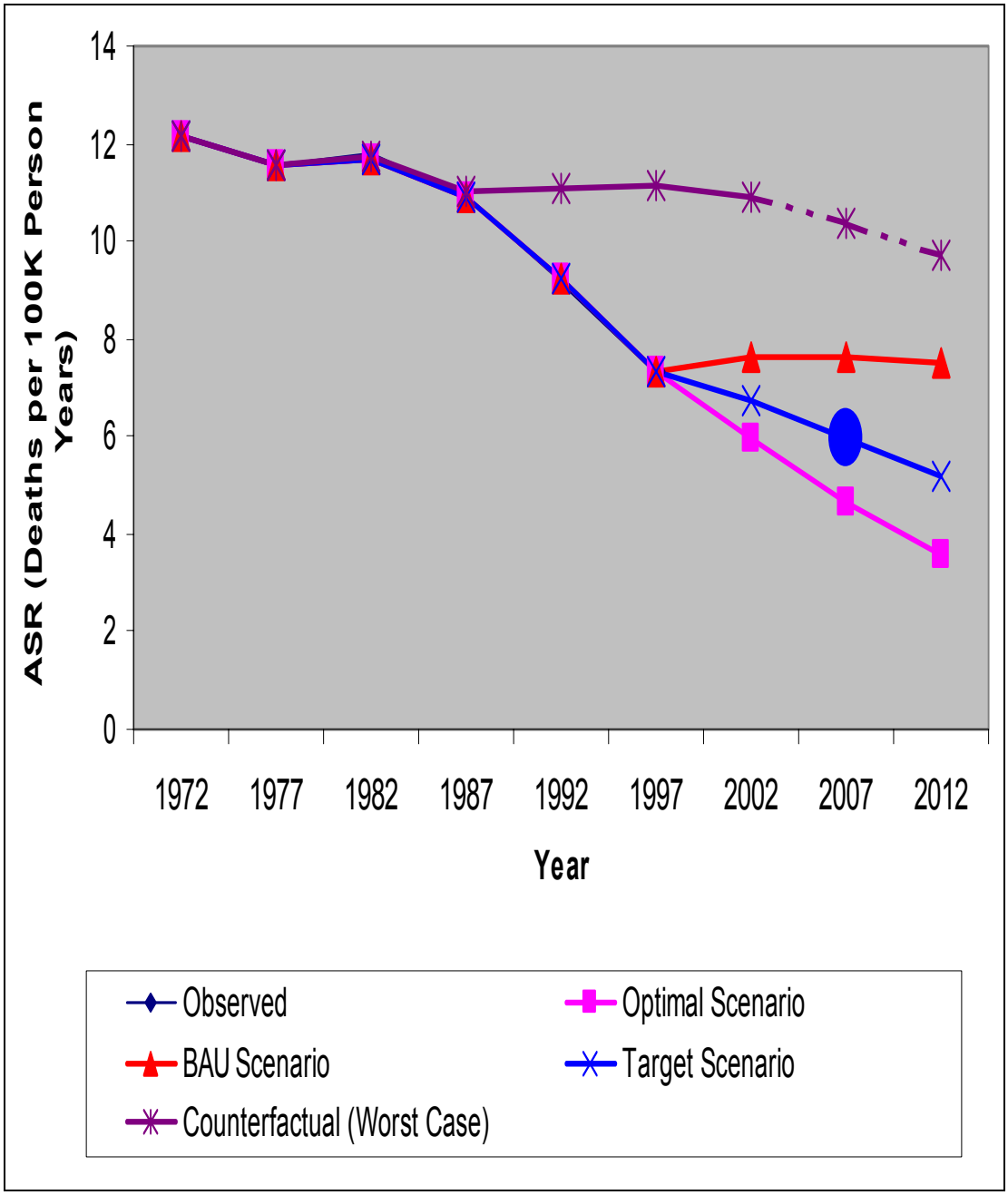


Figure 20: Age-standardised mortality rates for squamous cervical cancers (denominator unadjusted), 1972–2012

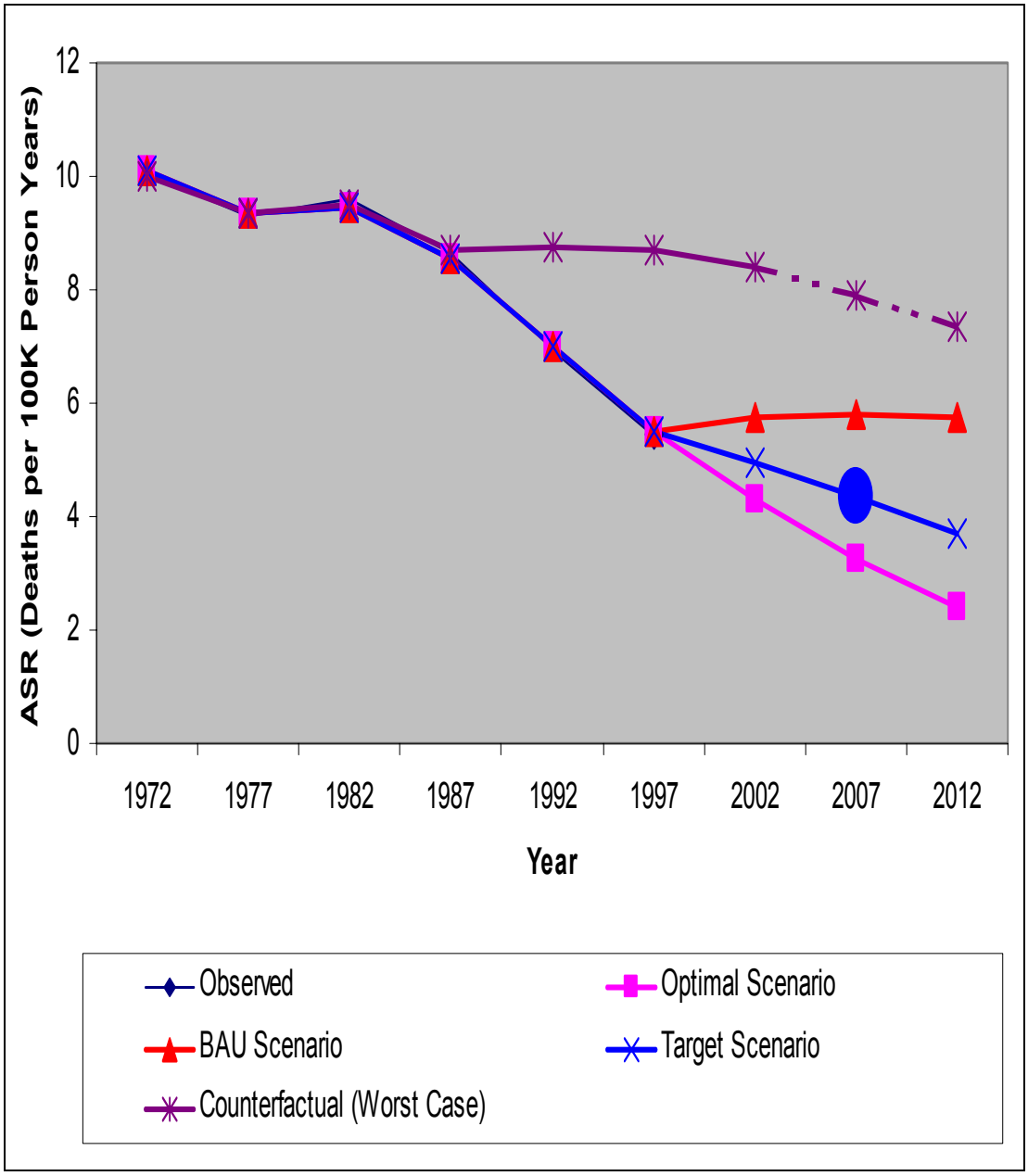
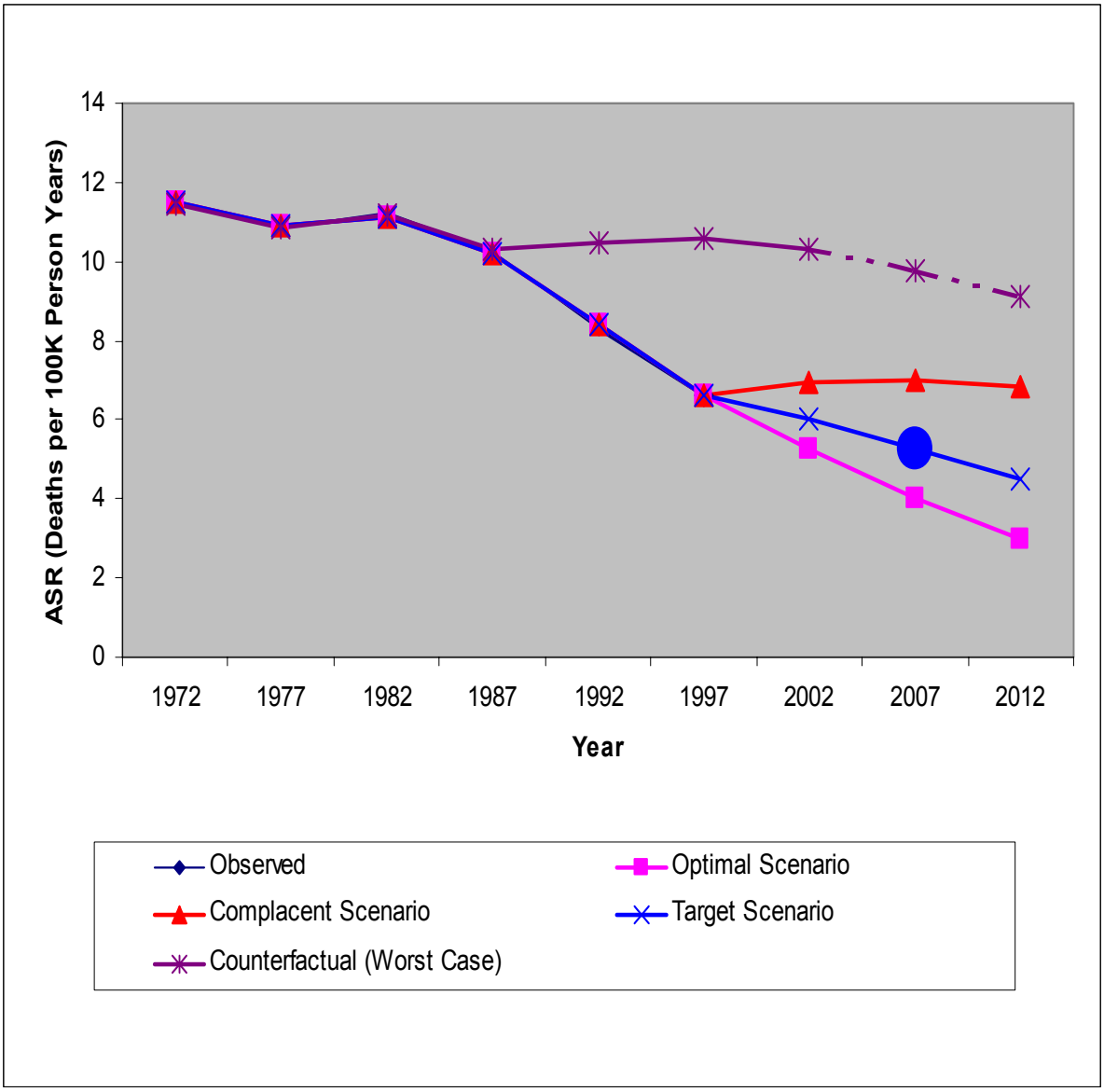


Figure 21: Age-standardised mortality rates for squamous cervical cancers (denominator hysterectomy-adjusted), 1972–2012



Once again, the trend of age-standardised mortality rates over time (under all scenarios) is similar for both squamous and all cervical cancers.

Unlike the incidence rates, however, it appears that the age-standardised mortality rate declines even under the counterfactual (worst-case) scenario, albeit relatively slowly. Intuitively this makes sense, in that there exists effective treatment for cervical cancer, provided it is detected early enough. Hence, irrespective of the screening programme, we can expect cervical cancer mortality to decline due to therapeutic advances.

Under the screening scenarios, the rate of decrease in mortality is even greater, as more cancers will be detected at a pre-invasive stage, thereby lowering mortality. Here, the period effect encompasses both treatment and screening effects.

Age-standardised mortality targets

Figures 22–24 summarise the age-standardised mortality targets obtained under the target scenario. Again, note that when the denominator is adjusted to reflect the hysterectomy-adjusted population, the targets are slightly higher.

Figure 22: Age-standardised mortality targets: all New Zealand women

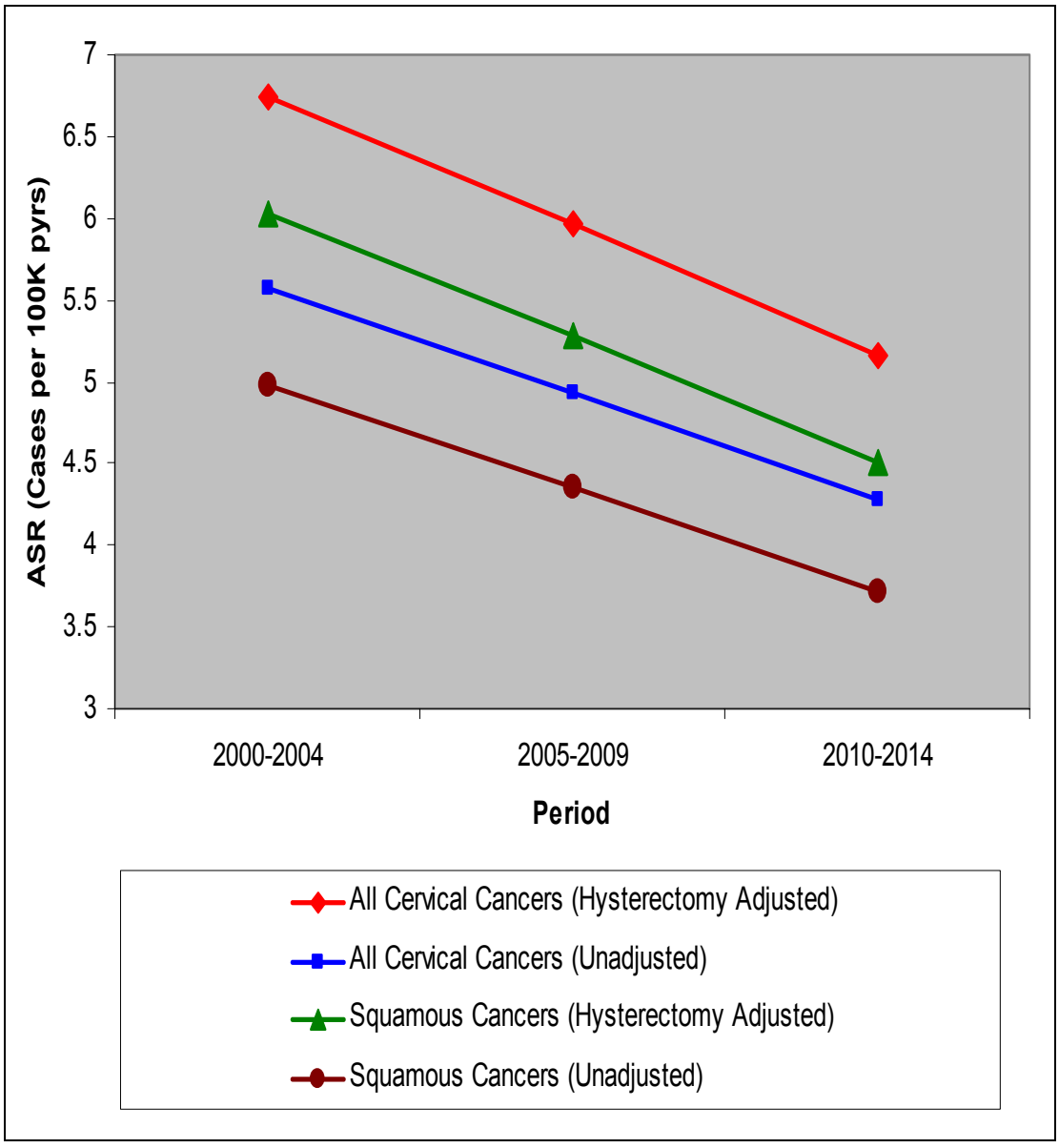


Figure 23: Age-standardised mortality targets: Māori women

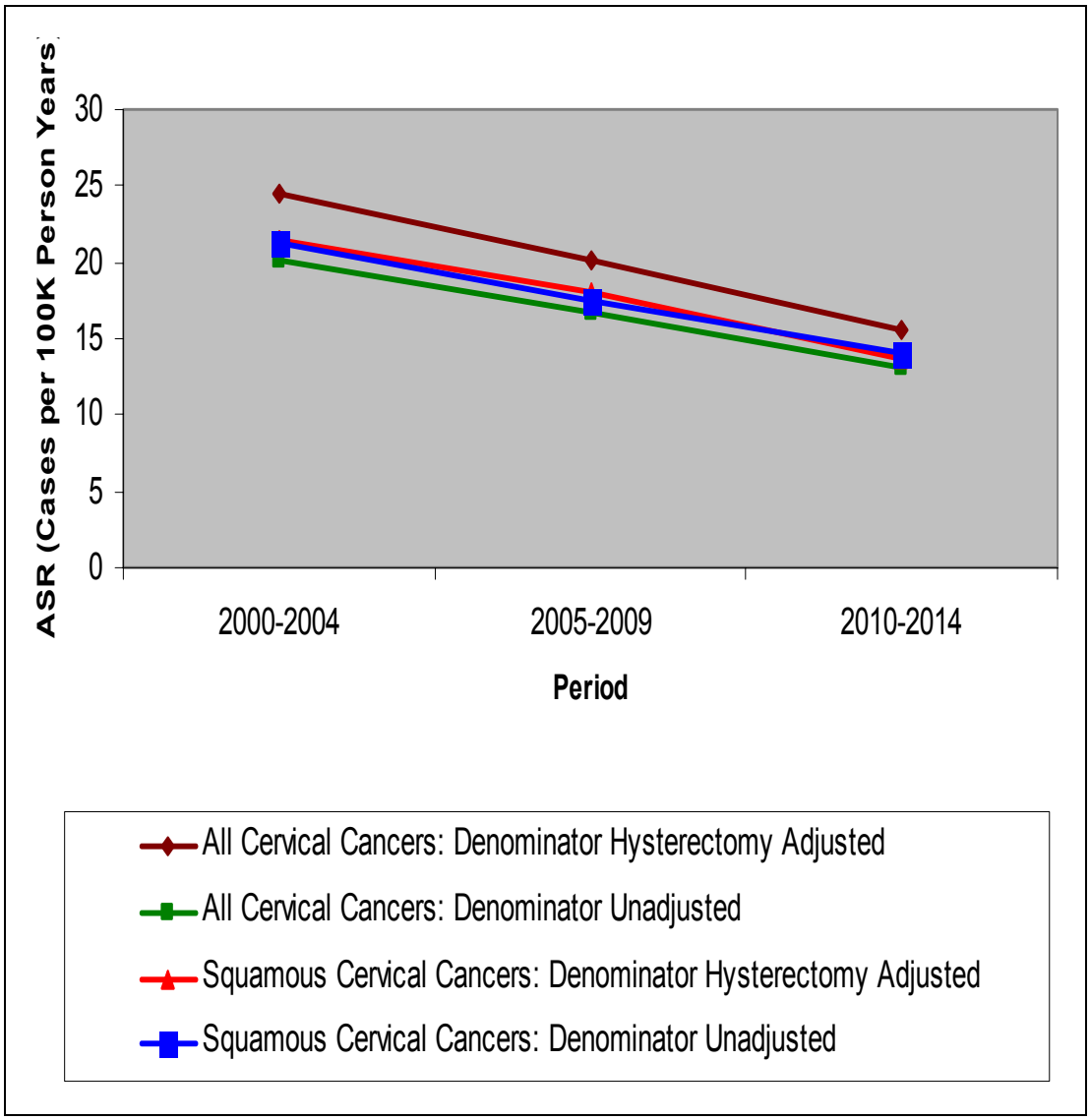


Figure 24: Age-standardised mortality targets: non-Māori women

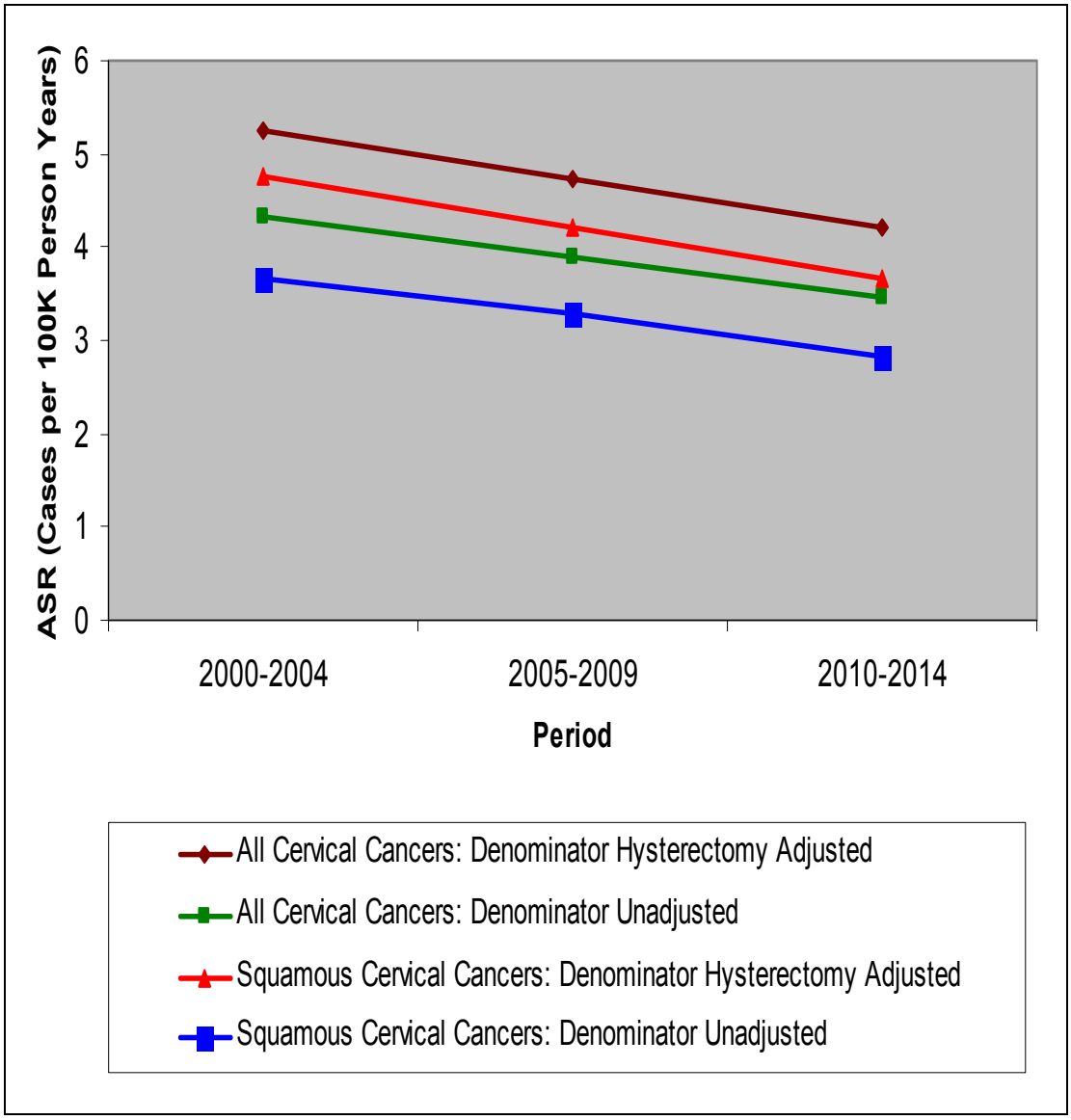


Table 15 summarises the recommended age-standardised mortality targets (expressed per 100,000 women aged 25–100+, standardised to the WHO world population, in bold). As before, rates standardised to a 0–100+ Segi population are also provided for comparison (in parentheses).

Table 15: Age-standardised mortality targets: all New Zealand women

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
Total population				
2006 Mortality	**6.0** (3.1)	**4.9** (2.6)	**5.3** (2.8)	**4.4** (2.3)
2011 Mortality	**5.2** (2.7)	**4.3** (2.3)	**4.5** (2.4)	**3.7** (2.0)
Māori population				
2006 Mortality	**20.2** (10.6)	**16.7** (8.8)	**18.1** (9.5)	**17.5** (9.2)
2011 Mortality	**15.6** (8.2)	**13.1** (6.9)	**13.7** (7.2)	**14.1** (7.4)
Non-Māori population				
2006 Mortality	**4.7** (2.5)	**3.9** (2.1)	**4.2** (2.2)	**3.3** (1.7)
2011 Mortality	**4.2** (2.2)	**3.5** (1.8)	**3.7** (1.9)	**2.8** (1.5)

Note: Rates in bold are per 100 000 women (25+ years), standardised to WHO world population; Rates in parentheses are per 100 000 females (0-100+ years), standardised to Segi's population

Age-specific mortality targets

Figures 25–30 and Tables 15 and 16 summarise the age-specific mortality targets (by 10-year age group). Again, note that the age-specific mortality rates vary considerably with age, and setting a target that is age-standardised may not be prudent. For example, as with incidence, the gap between Māori and non-Māori women is negligible in the youngest age group and very large in middle-aged women.

Figure 25: Age-specific mortality targets: total population (2005–09)

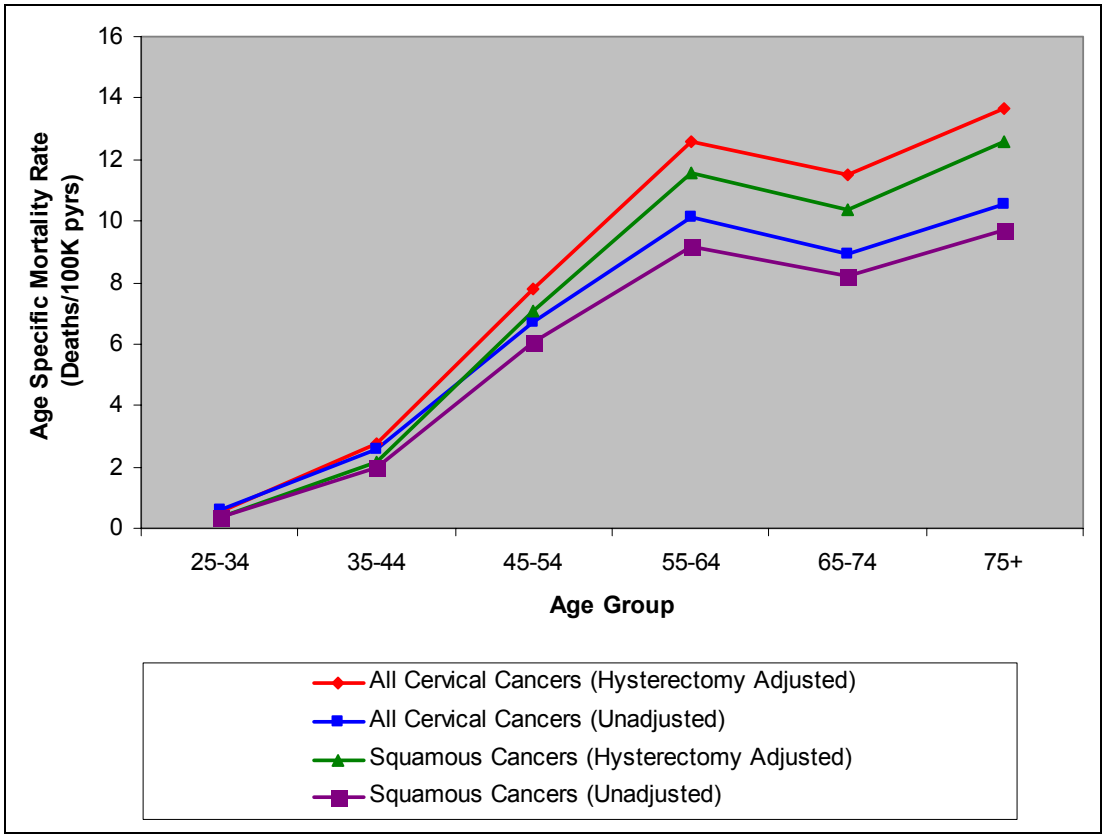


Figure 26: Age-specific mortality targets: total population (2010–14)

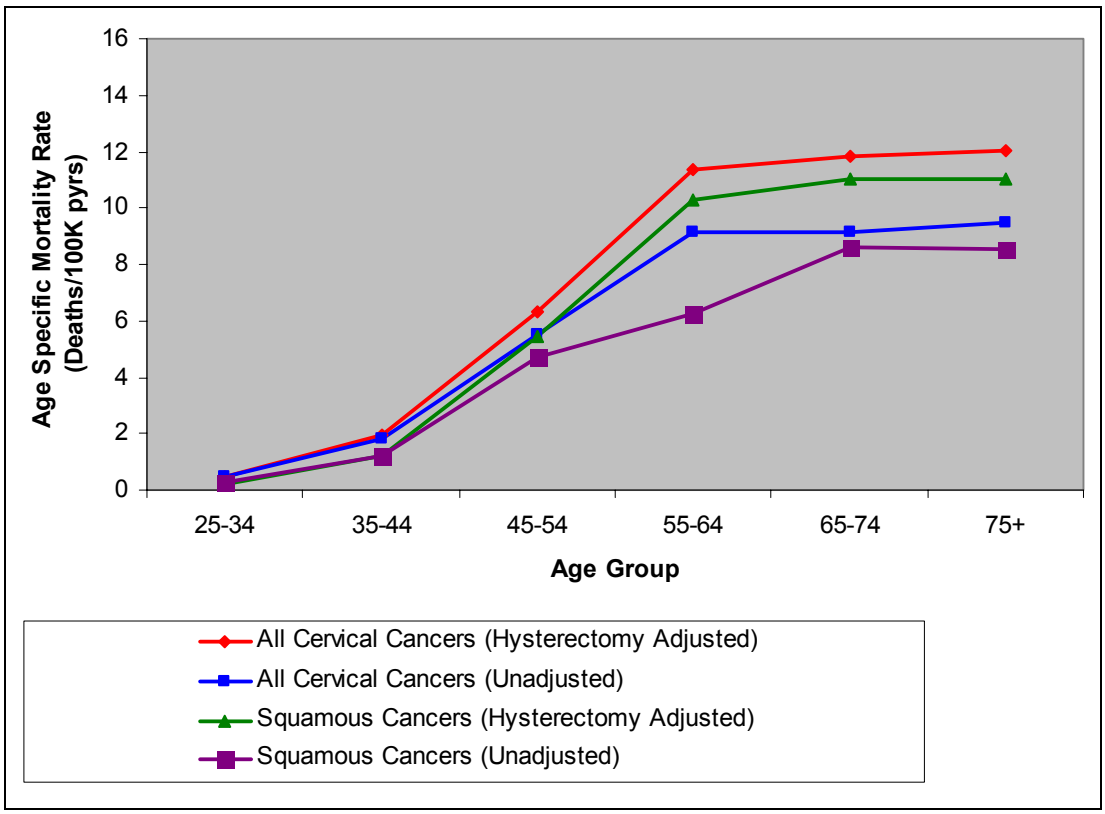


Figure 27: Age-specific mortality targets: Māori population (2005–09)

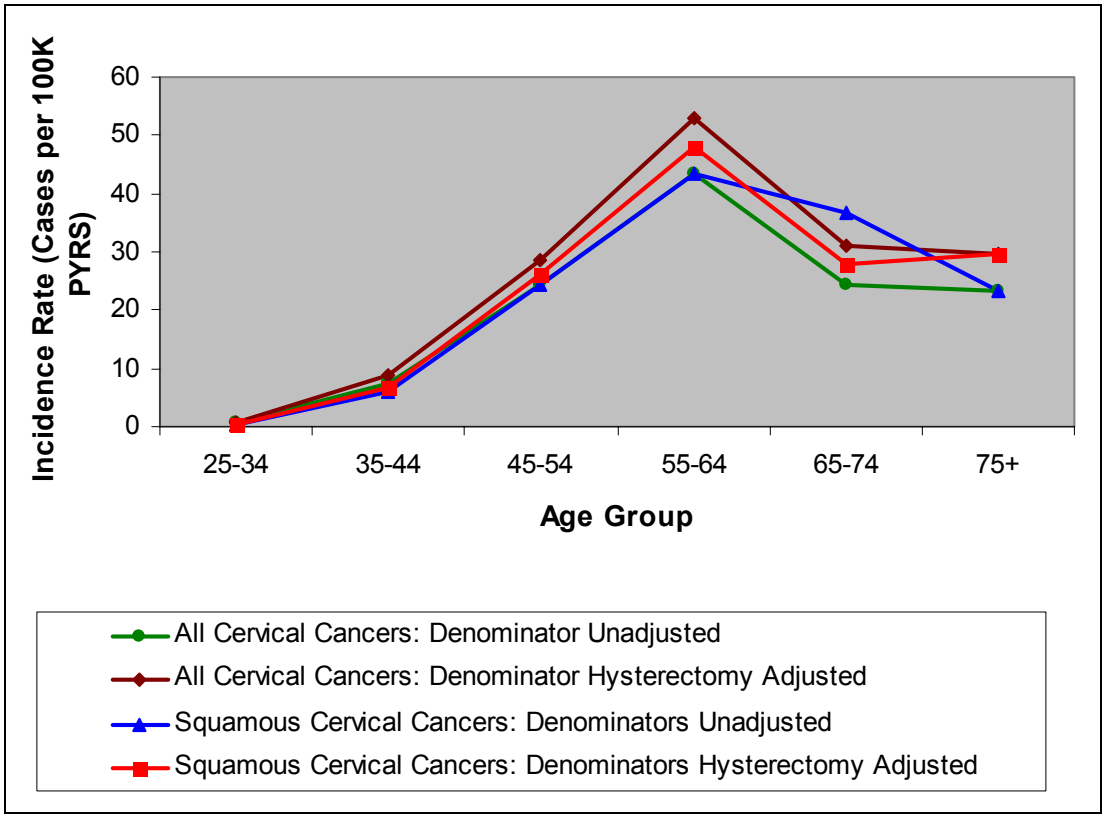


Figure 28: Age-specific mortality targets: Māori population (2010–14)

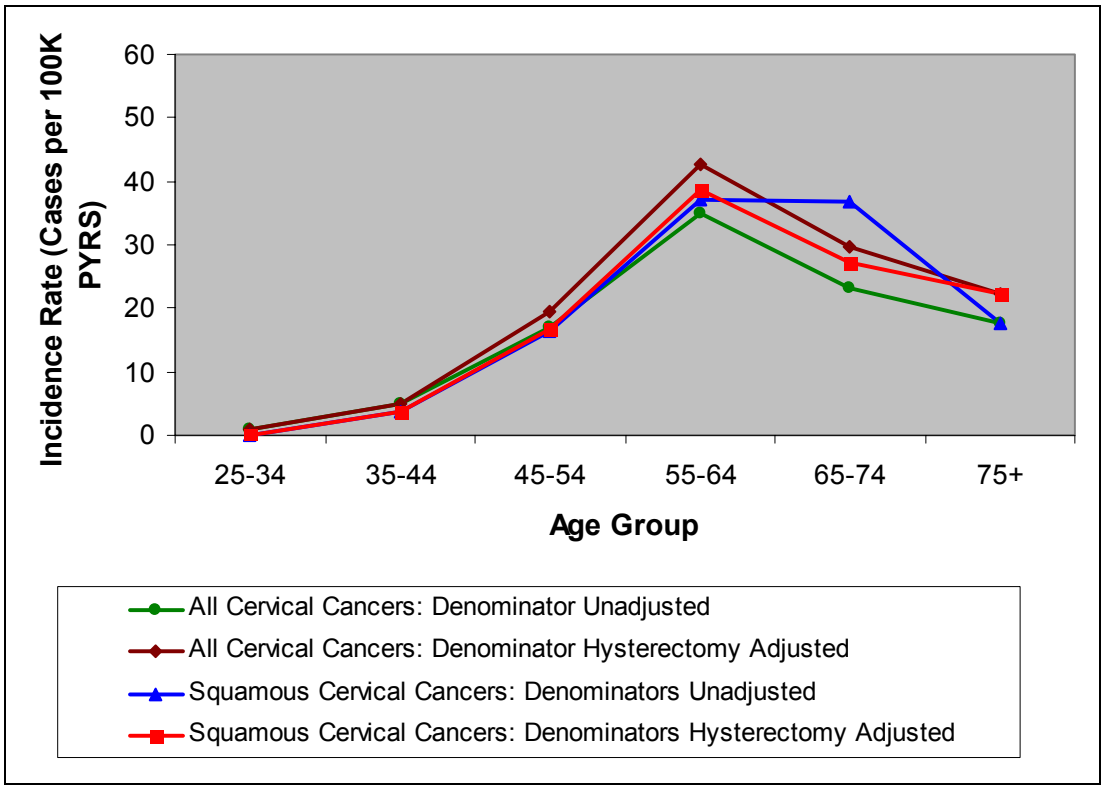


Figure 29: Age-specific mortality targets: non-Māori population (2005–09)

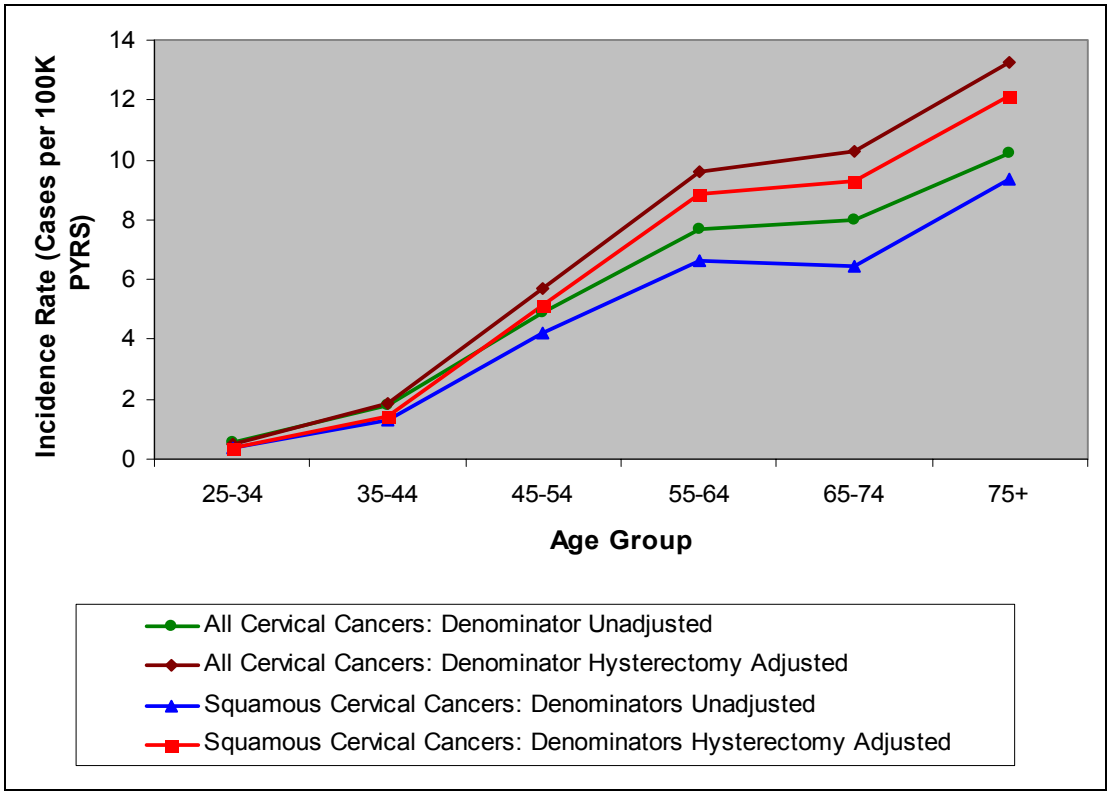


Figure 30: Age-specific mortality targets: non-Māori population (2010–14)

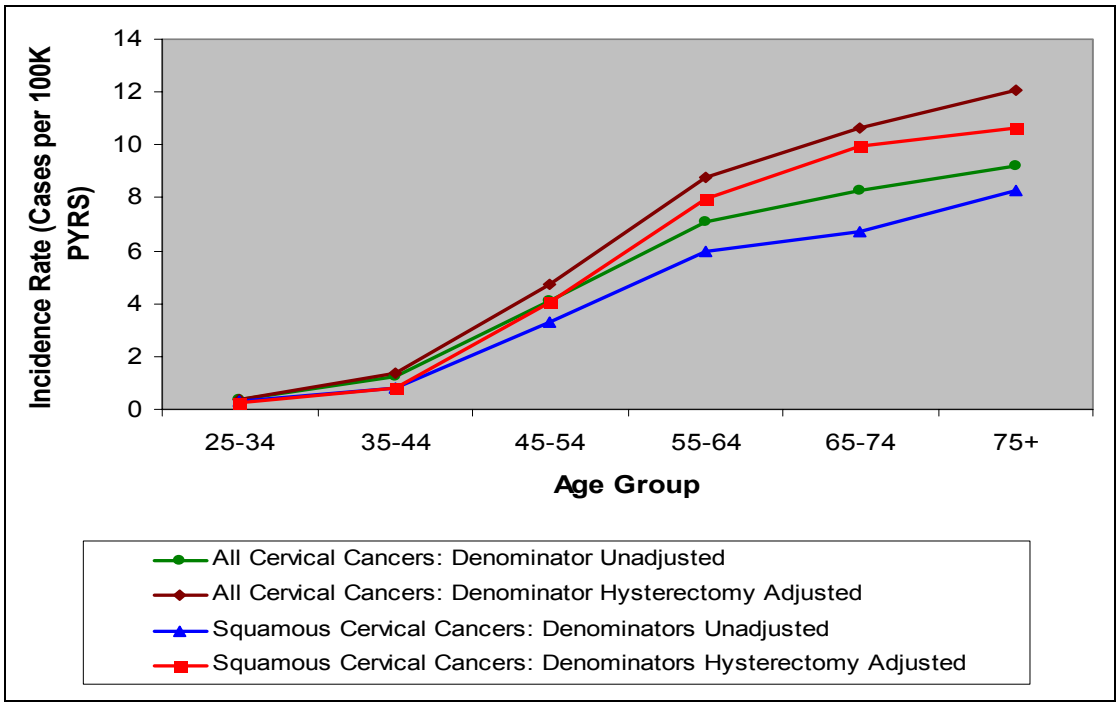


Table 16: Age-specific mortality targets, 2005–09

Age group (years)	All cervical cancers	Squamous cancers

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
Total population				
25–34	0.5	0.6	0.4	0.4
35–44	2.8	2.6	2.1	2.0
45–54	7.8	6.7	7.0	6.1
55–64	12.6	10.1	11.6	9.1
65–74	11.5	8.9	10.4	8.2
75+	13.7	10.5	12.6	9.7
Māori population				
25–34	0.9	0.8	0.4	0.4
35–44	8.7	7.5	6.8	6.1
45–54	28.6	24.4	26.1	24.4
55–64	52.8	43.5	47.8	43.5
65–74	31.0	24.4	27.9	36.6
75+	29.6	23.4	29.6	23.4
Non-Māori population				
25–34	0.5	0.5	0.4	0.4
35–44	1.9	1.8	1.4	1.3
45–54	5.7	4.9	5.1	4.2
55–64	9.6	7.7	8.9	6.6
65–74	10.3	8.0	9.3	6.5
75+	13.3	10.2	12.1	9.3

Note: Rates are per 100 000 in age group

Table 17: Age-specific mortality targets, 2010–14

Age group (years)	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
Total population				
25–34	0.5	0.5	0.2	0.2
35–44	1.9	1.8	1.2	1.2
45–54	6.3	5.5	5.5	4.7
55–64	11.4	9.2	10.3	6.2
65–74	11.8	9.2	11.1	8.6
75+	12.0	9.5	11.0	8.5
Māori population				
25–34	0.9	0.9	0.0	0.0
35–44	5.1	5.0	3.7	3.6
45–54	19.4	17.0	16.8	16.4
55–64	42.6	34.9	38.7	37.1
65–74	29.6	23.2	27.1	36.7
75+	22.4	17.6	22.4	17.6
Non-Māori population				
25–34	0.4	0.4	0.3	0.3
35–44	1.4	1.2	0.8	0.8
45–54	4.7	4.1	4.1	3.3
55–64	8.8	7.1	7.9	6.0
65–74	10.6	8.3	10.0	6.7
75+	12.1	9.2	10.6	8.3

Note: Rates are per 100 000 in age group

Comparison with existing targets

The existing targets (which are age-standardised rates for 2005) can be compared with the recommended all cervical cancer non-hysterectomy-adjusted targets for 2006 for all women and Māori women (with rates expressed per 100,000 females of all ages standardised to Segi's).

Table 18: Comparison of existing and recommended mortality targets

	All women	Māori women
Existing target	3.5	5.3
Recommended target	2.6	8.8

Note: Rates are per 100 000 females (0-100+ years), standardised to Segi's population

The recommended target for all New Zealand women (when expressed in similar terms) is below the existing target. This may reflect a more rapid decline in

mortality in the 1990s than expected. However, the recommended target for Māori women is much higher than the existing target. This may reflect in part our correction for the (severe) undercounting of Māori mortality.

Estimating screening impact

Figures 31 and 32 illustrate the number of deaths by period and the cumulative number of deaths (respectively) that have been averted due to screening (formal and informal). The number of deaths averted is obtained by comparing the actual number of observed deaths to the estimated number under the counterfactual scenario.

Mortality data for the 2000–04 period were unavailable. The number of estimated deaths averted during this period is based on projections under the target scenario. Strictly speaking these figures do not reflect deaths averted to date, per se, as the last five-year period includes 2004.

Table 18 summarises the estimated number of deaths averted due to 'screening'. Note that these estimates actually represent the *combined* effects of screening and improvements in medical treatment of cervical cancer since the early 1990s.

As found in the analysis of number of incident cases averted due to screening, there is a discrepancy between the number of deaths averted when the denominator is adjusted to reflect the hysterectomy-adjusted population.

Also, as before, the number of squamous deaths averted is greater than the number of all cervical cancer deaths averted, which of course is not possible, but is attributable to the modelling process.

Table 19: Number of deaths averted due to screening

	All cervical cancers		Squamous cancers	
	Hysterectomy-adjusted population	Unadjusted population	Hysterectomy-adjusted population	Unadjusted population
1990–94	85	83	95	93
1995–99	198	191	202	196
2000–04[10]	*239*	*224*	*245*	*233*

From Table 19, we estimate that the number of deaths averted by 'screening' from 1990–91 to 2004 will be approximately 540 (using the squamous-hysterectomised model), but could be as low as approximately 500 (using the all cancer-unadjusted model).

[10] Based on projections.

Figure 31: Estimated number of cervical cancer deaths averted due to screening

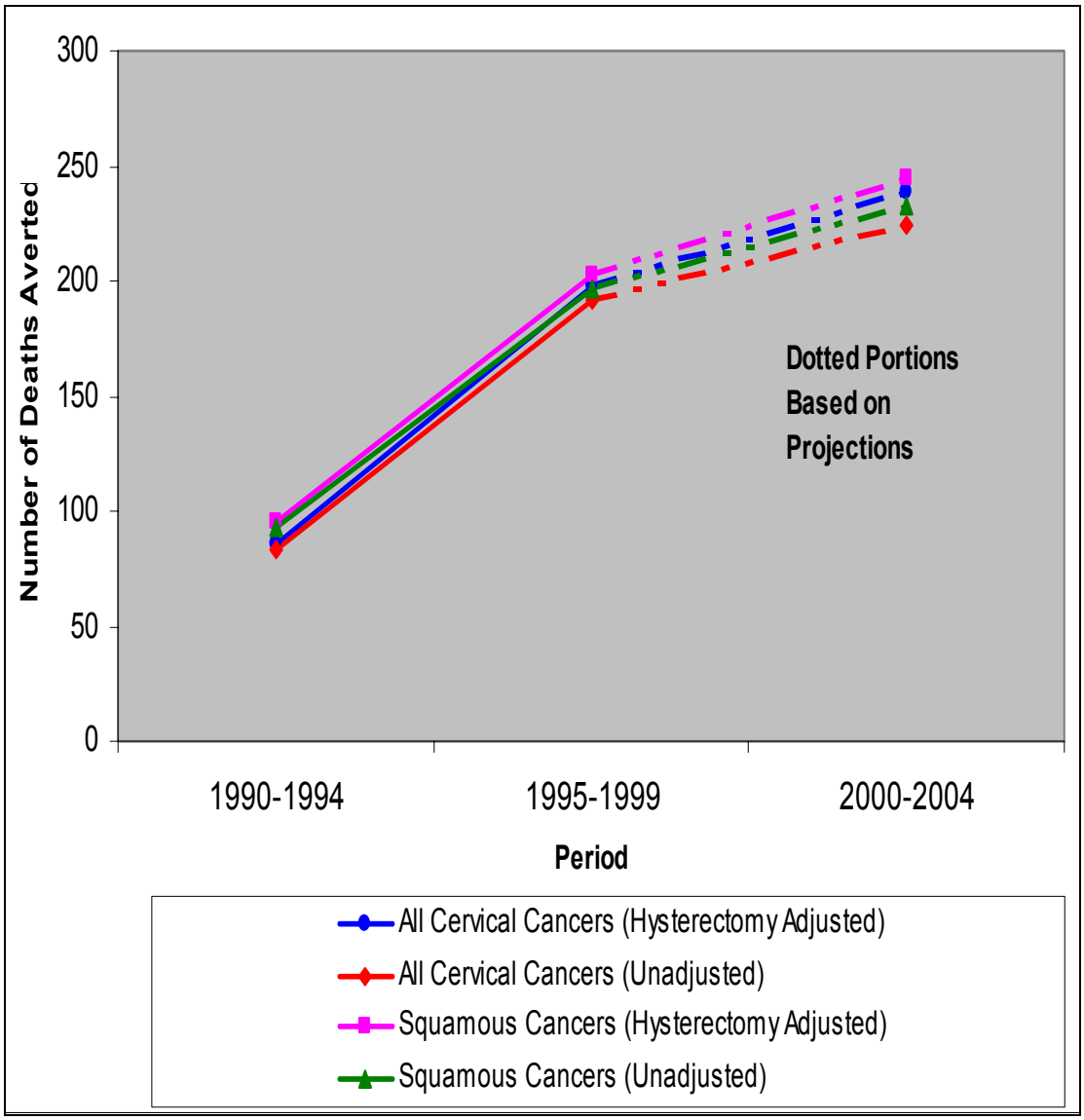
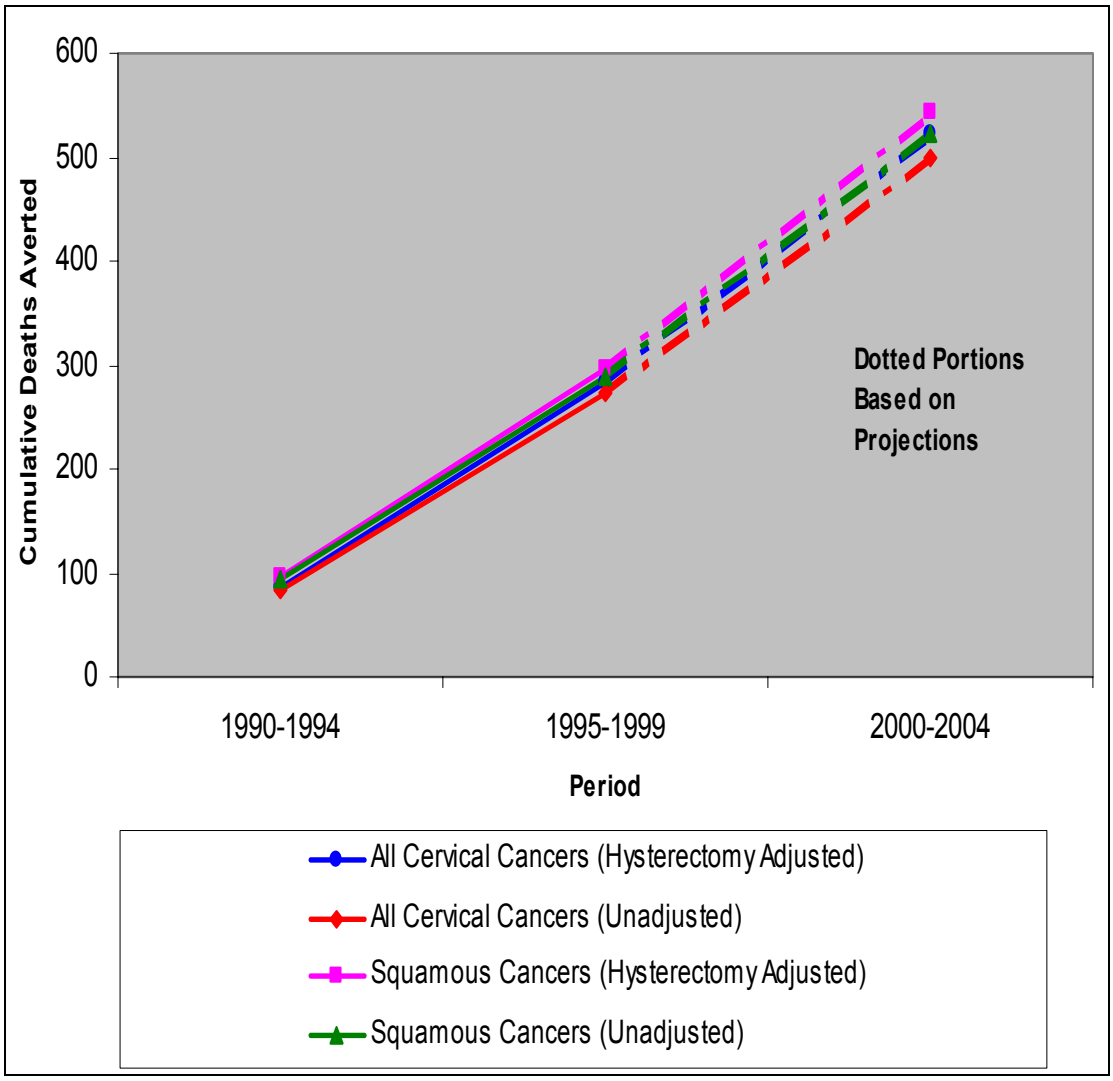


Figure 32: Estimated number of cumulative cervical cancer deaths averted due to screening



Conclusion

Limitations of the classical APC model

While projections obtained using the age-period-cohort modelling approach are largely unaffected by the non-identifiability problem, it is still desirable to obtain effect estimates that are sensible, as these parameters can give us valuable insight into the effectiveness of the screening programme, as well as cohort specific information. Nevertheless, it is important that these effect estimates not be over-interpreted.

Alternatives to the classical approach include Bayesian models, which use autoregressive priors for the age, period and cohort parameters to obtain distributions of the desired parameters using Markov Chain Monte Carlo techniques. Another approach is to use generalised additive models, which do not impose any parametric assumptions on the Poisson (incidence or mortality) rate parameter. Hodgen (2003) includes a thorough discussion of the various alternatives (along with their advantages and disadvantages) to the classical APC approach.

We examined several alternative APC modelling approaches, but in the end concluded that none offered any real advantage over the classical approach for our purposes.

Microsimulation modelling provides a completely different approach to modelling, and one that should be considered when the next opportunity arises to reset these targets. This approach offers the advantage of explicitly modelling important programme variables while not being subject to combinatorial limitations, but is very data demanding.

Target setting

Setting age-specific targets versus age-standardised targets

We have provided both age-standardised and age-specific targets in this report. It is important to be cautious when dealing with age-standardised rates. A lot of information can be lost when rates are age-standardised. In particular, the age-specific rates can vary in different directions for different age groups, reflecting mainly cohort effects.

Also note that we have provided age-standardised rates restricted to the 25–79 age group for incidence and the 25–100+ age group for mortality. This is because rates should be calculated only for persons at risk.[11] However, the existing targets are calculated for the female population of all ages (0–100+). Also, our age-

[11] While incident cases of cervical cancer are sometimes observed in the 15–24-year-old age group this is quite rare. Thus, we felt that it was prudent to omit this age group when standardising incidence rates. Deaths from cervical cancer in this age group are rarer still, and hence this age group has also been omitted when standardising mortality rates.

standardised rates have been directly standardised to the WHO world population, whereas the existing targets are standardised to Segi's reference population. To permit comparison, we also provide our targets expressed per 100,000 females aged 0–100+ standardised to Segi's reference population.

Setting hysterectomy-adjusted targets

We believe that in calculating incidence and mortality rates, the appropriate denominator to use is non-hysterectomised women. Conventionally, the denominator in any incidence or mortality rate should reflect the *person years at risk*. Women who have had hysterectomies have a negligible risk of cervical cancer, except for the small proportion (probably less than 10 percent) for whom the indication for hysterectomy was in fact treatment of cervical cancer.[12] Failing to adjust for the prevalence of hysterectomy therefore underestimates the magnitude of the target rate (by including a larger than necessary denominator).

On the other hand, adjusting for hysterectomy introduces an additional source of uncertainty (especially for the Māori targets), so both adjusted and unadjusted targets are provided.

Setting targets for squamous versus all cervical cancer

We believe that the NCSP should focus on targets for squamous cancer incidence and mortality, since the programme is largely ineffective at screening for adenocarcinoma. If the purpose of the targets is to assist in programme planning and resource allocation, and help evaluate programme effectiveness, then it would be prudent to give more weight to the squamous than to the 'all cancer' targets.

On the other hand, the existing targets are framed inclusively, and most international literature considers only cervical cancer as a whole. The more inclusive approach also removes one source of uncertainty – variation in the quality of morphological classification of invasive cervical cancers. For these reasons, we provide both targets for squamous and for all cervical cancers.

Setting ethnic specific targets

Setting ethnic specific targets required the use of various assumptions, given the poor quality of ethnicity data on health records in the past. It also required the use of adjusters for the Māori undercount, based on linkage to hospitalisation records for incidence and to the census (ie use of the adjusters from the New Zealand Census – Mortality Study) for mortality. Nevertheless, we believe that ethnic specific, as well as all New Zealand, targets should be set in view of the very different risks faced by Māori women.

[12] We do not correct for this in our model, as the impact is very slight.

The much higher mortality to incidence ratio for Māori than non-Māori women is particularly concerning.[13] Estimates of ethnic specific five-year relative survival are available for the 1994–2001 period (Stevanovich V, personal communication, May 2003), and confirm the higher case fatality of Māori women. Part of the worse survival of Māori women may be associated with a right-shifted distribution of stage at presentation, but five-year relative survival remains 90 percent lower than that of non-Maori women even after adjustment for this and several other variables.

The targets recommended for Māori are based on the target scenario, as is the case for non-Māori women. Achieving these targets will therefore largely maintain the gap between the ethnic groups. Hence every effort should be made to exceed the recommended targets for Māori, especially for mortality, in order to narrow the ethnic disparity.

'Key' outcome targets

Throughout this report we have presented targets derived using different numerators and denominators (ie, using hysterectomy-adjusted versus unadjusted denominators and squamous versus all cervical cancers numerators). We recommend that the NCSP should regard the targets for the *squamous series derived using a hysterectomy-adjusted population* as the 'key' targets.

These targets are summarised in Tables20–23 and Figures 33–38, and are also presented in Appendix 5, where they are expressed both as rates and as counts.

[13] Mortality rates exceed incidence rates only for Māori women aged 55–64 and 65–74 using the squamous / hysterectomy-unadjusted model (both 2005–09 and 2010–14 periods). This suggests that inconsistency arising from independent modelling of incidence and mortality is not important.

Figure 33: Recommended 'key' age-standardised incidence targets by ethnicity (squamous series, hysterectomy-adjusted)

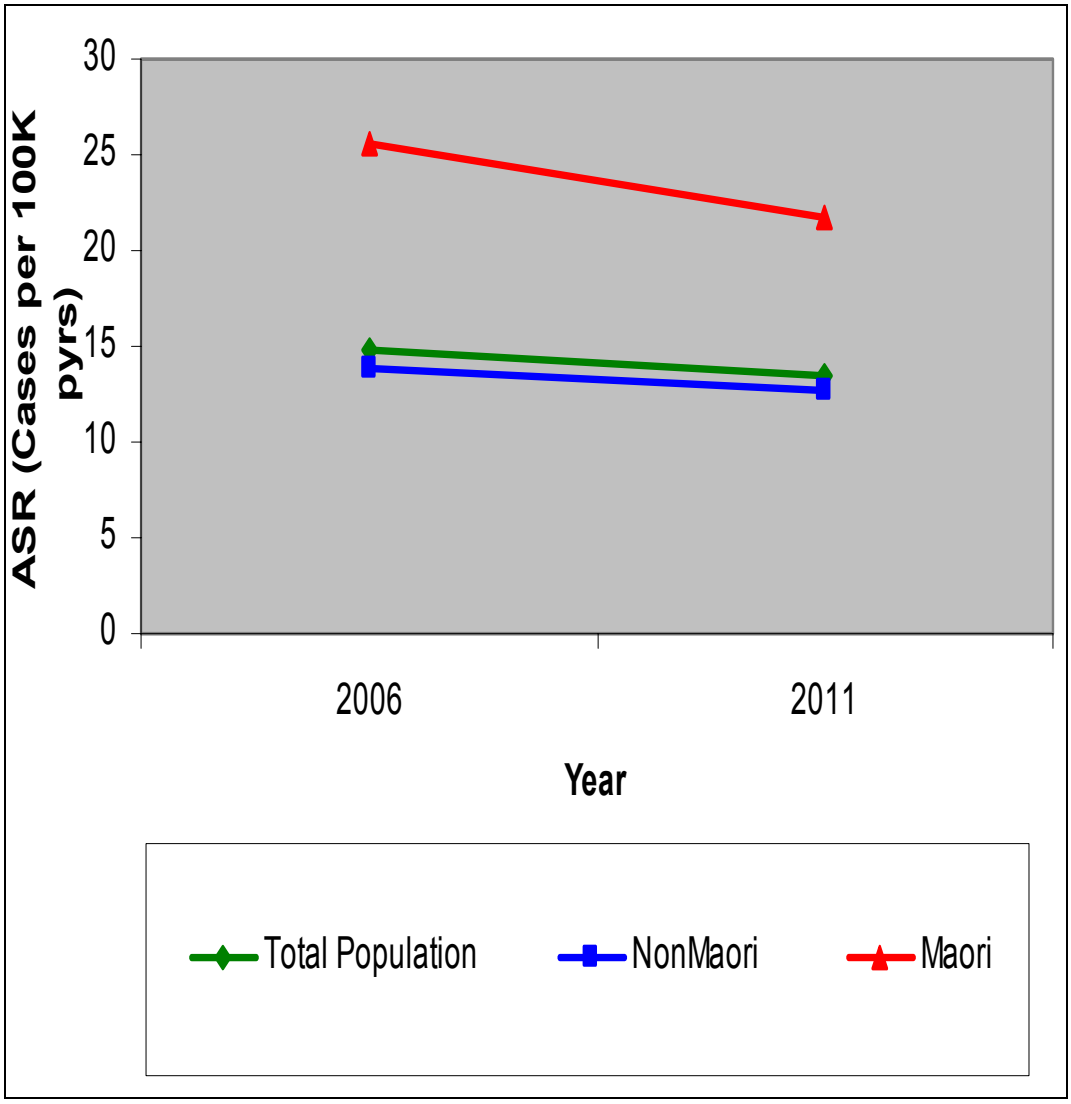


Figure 34: Recommended 'key' age-standardised mortality targets by ethnicity (squamous series, hysterectomy-adjusted)

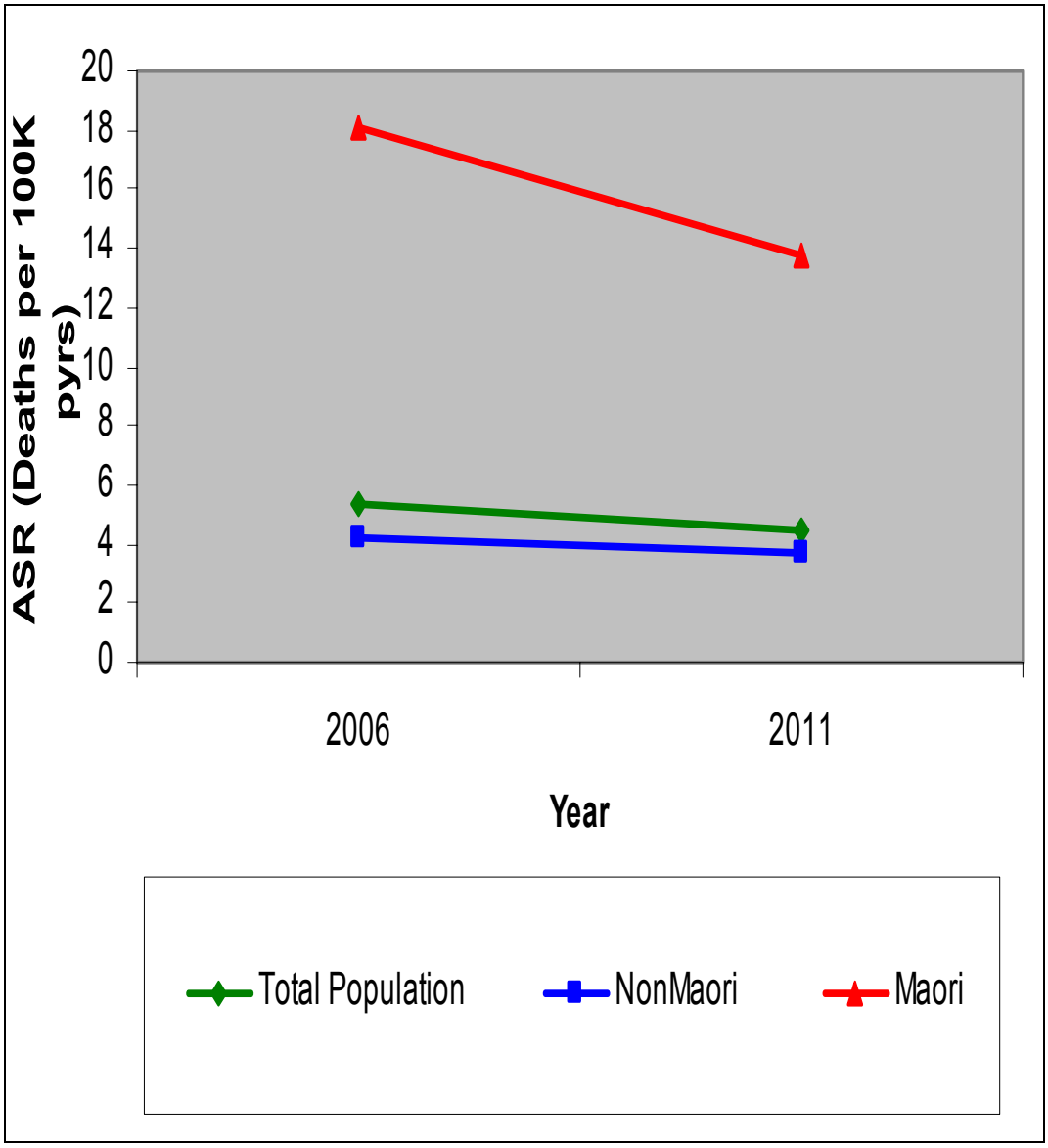


Table 20: Summary of 'key' age-standardised targets squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
Total population	**14.9**	**13.5**	**5.3**	**4.5**
	(7.9)	(7.1)	(2.8)	(2.4)
Māori	**25.5**	**21.8**	**18.1**	**13.7**
	(13.5)	(11.5)	(9.5)	(7.2)
Non-Māori	**13.8**	**12.6**	**4.2**	**3.7**
	(7.3)	(6.7)	(2.2)	(1.9)

Note: Rates in bold are per 100,000 women aged 25–79 years for incidence and 25+ years for mortality, standardised to WHO world population. Rates in (parentheses) are per 100,000 females aged 0–100+, standardised to Segi population.

Table 21: Summary of key age-specific targets: total population (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	5.9	5.0	0.4	0.2
35–44	14.8	12.3	2.1	1.2
45–54	22.1	19.6	7.0	5.5
55–64	22.7	22.2	11.6	10.3
65–74	14.9	15.4	10.4	11.1
75+	3.2	2.5	12.6	11.0

Note: Rate per 100 000 in age group

Table 22: Summary of key age-specific targets: Māori population (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	5.8	4.9	0.4	0.0
35–44	20.1	16.5	6.8	3.7
45–54	33.0	27.4	26.1	16.8
55–64	48.0	41.0	47.8	38.7
65–74	40.3	40.9	27.9	27.1
75+	23.4	16.8	29.6	22.4

Note: Rate per 100 000 in age group

Table 23: Summary of key age-specific targets: non-Māori population (squamous series, hysterectomy-adjusted)

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	6.0	5.0	0.4	0.3
35–44	14.0	11.8	1.4	0.8
45–54	21.0	19.0	5.1	4.1
55–64	20.0	19.6	8.9	7.9
65–74	12.7	13.0	9.3	10.0
75+	4.1	3.3	12.1	10.6

Note: Rate per 100 000 in age group

Figure 35: Recommended 'key' age-specific incidence targets by ethnicity (2006) (squamous series, hysterectomy-adjusted)

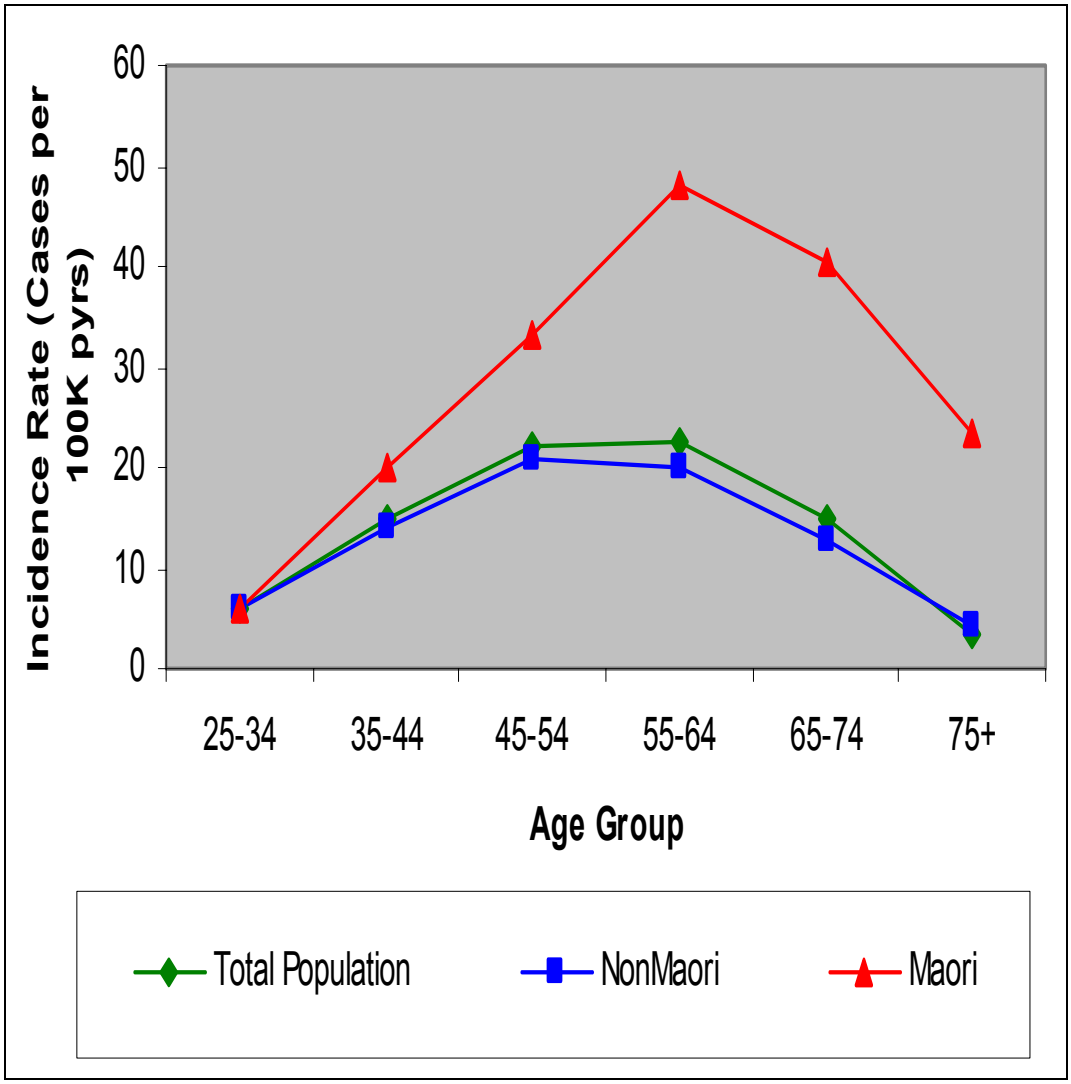


Figure 36: Recommended 'key' age-specific incidence targets by ethnicity (2011) (squamous series, hysterectomy-adjusted)

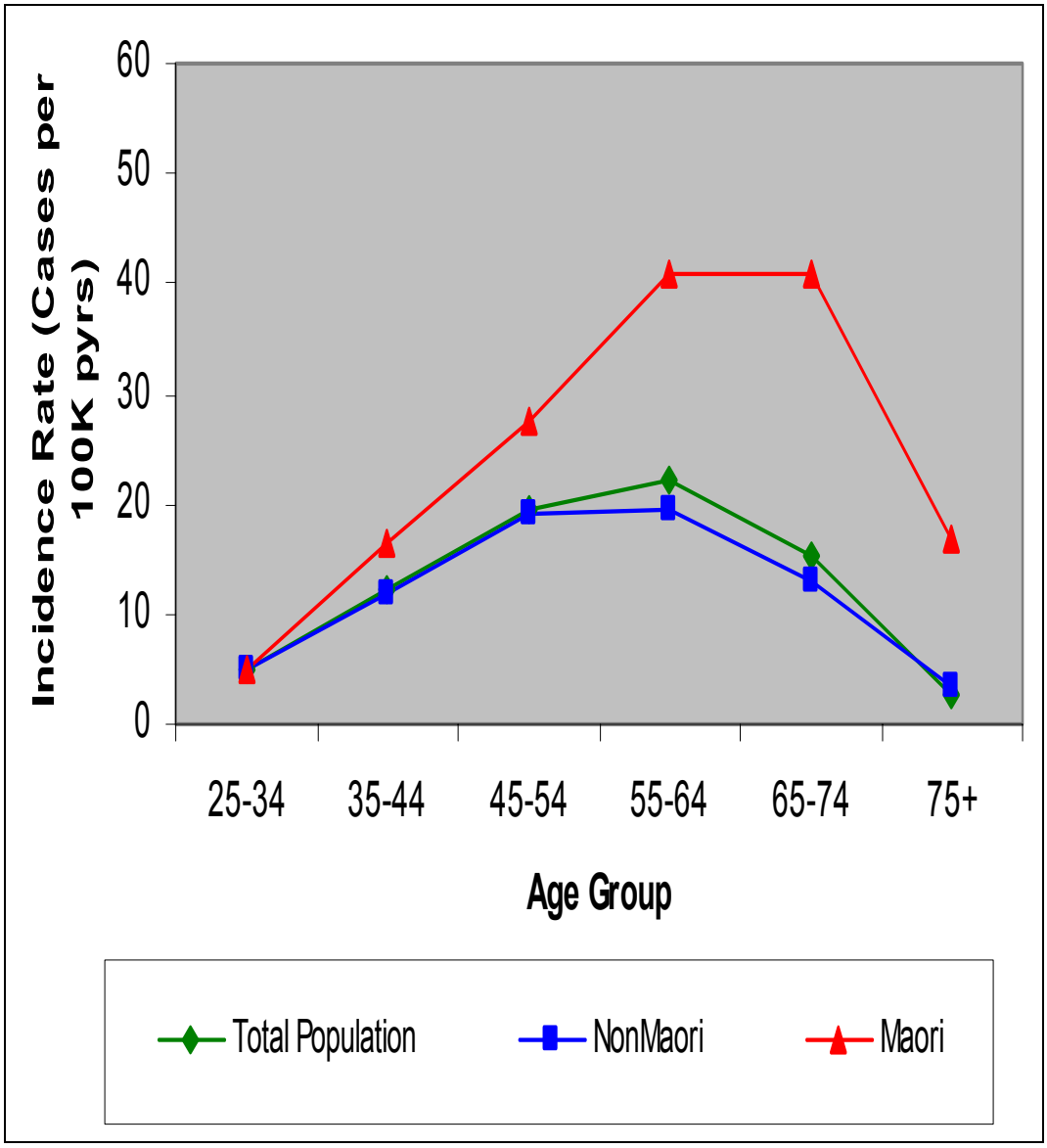


Figure 37: Recommended 'key' age-specific mortality targets by ethnicity (2006) (squamous series, hysterectomy-adjusted)

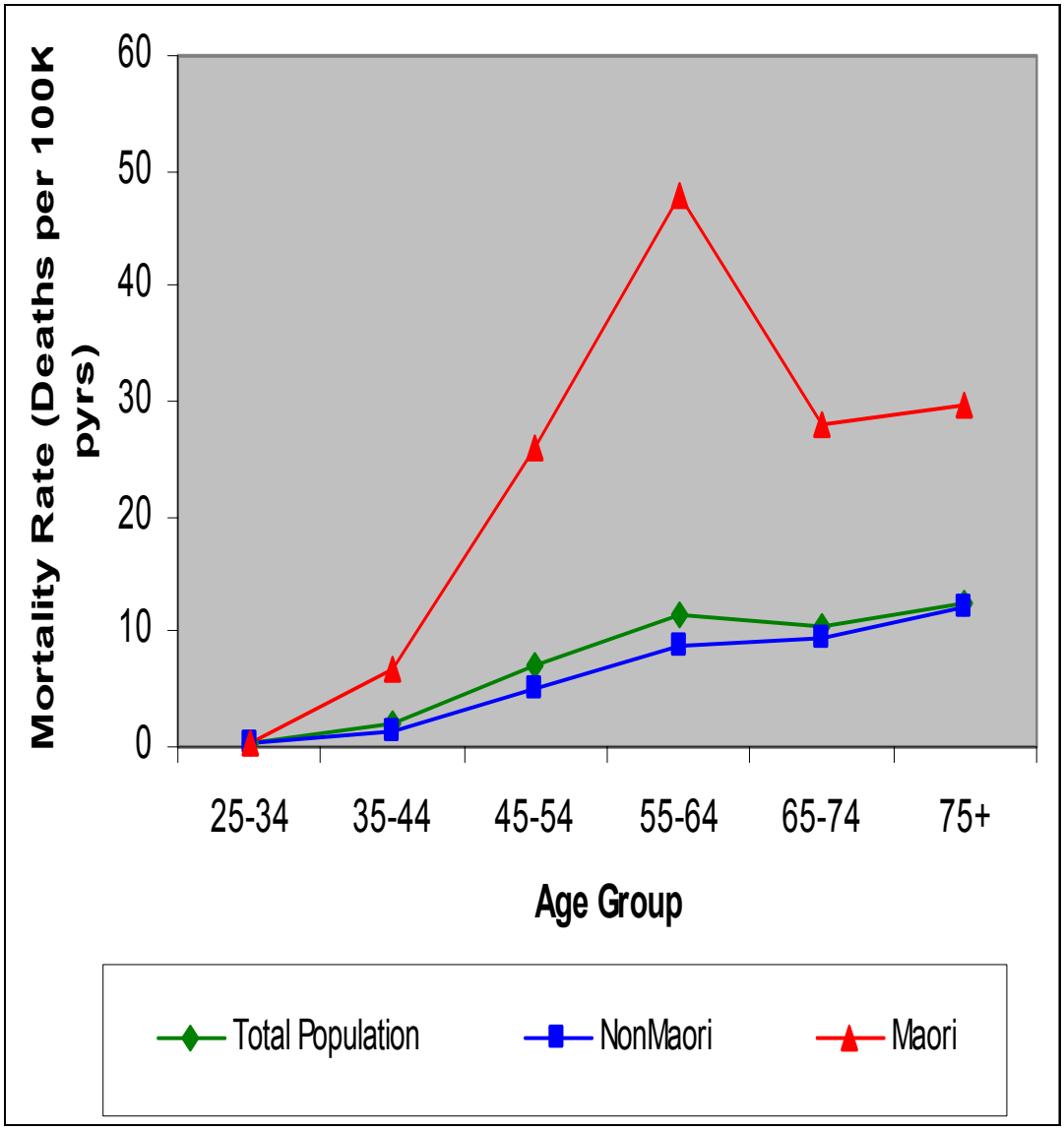
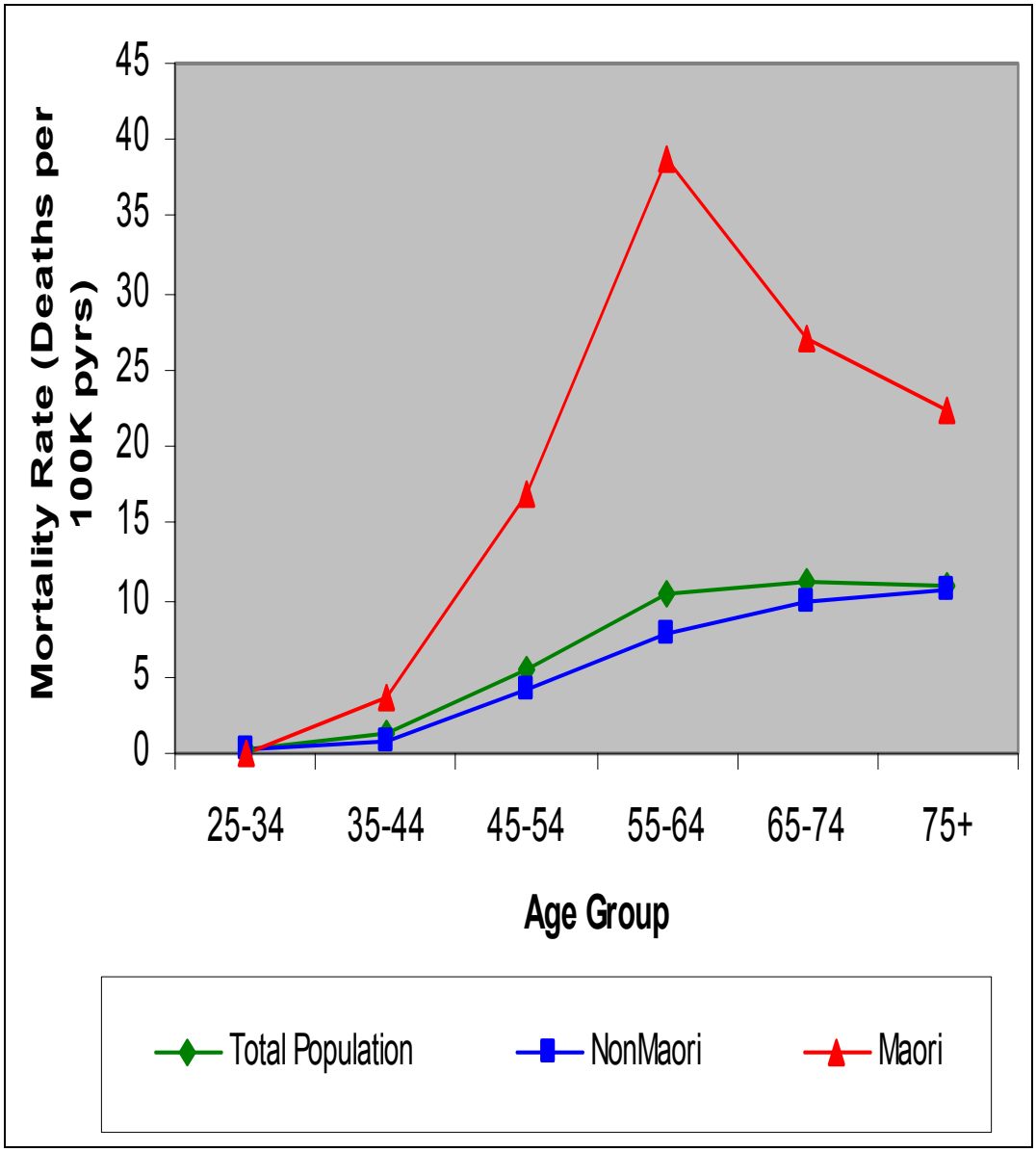


Figure 38: Recommended 'key' age-specific mortality targets by ethnicity (2011) (squamous series, hysterectomy-adjusted)



Setting challenging yet achievable targets

The target scenario, with a trajectory midway between the optimal and BAU scenarios, is intended to represent a challenging yet potentially achievable target for which to aim.

For Māori women – whose current coverage is much lower than that of non-Māori women (Ministry of Health 2002a) – it may be possible to exceed this target. This would reduce the ethnic inequality in the cervical cancer burden.

The BAU scenario shows however that, if no further improvement in programme coverage and quality occurs over and above what is currently in place, then (age-standardised) incidence rates will soon begin to increase once more. This 'rebound' phenomenon is due to cohort effects.

This anticipated rebound has major implications for the NCSP: it implies that substantial improvements in programme coverage and quality will have to be made just to maintain the gains of the past decade, never mind further reducing incidence rates and counts. At the same time, limits exist on the extent to which programme coverage can further improve, particularly among non-Māori women.

The cohort effect together with the coverage saturation effect explains why the recommended targets have been set midway between the BAU and optimal scenarios, so projecting only limited further gains (especially in terms of incidence). Achieving even these limited gains will be very challenging indeed.

Screening impact to date (and projected)

From the counterfactual scenario we estimate that approximately 2650 incident cases of cervical cancer and 540 cervical cancer related deaths have been averted from the early 1990s to date (2003 and 2004 respectively) through screening, although not all of this impact is attributable to the formal screening programme. In particular, the mortality impact includes both screening and treatment effects.

Figures 39 and 40 show the estimated number of cases and deaths that will be averted up to 2011 if the screening programme targets outlined above are achieved.[14]

If the target scenario is realised, we estimate that by 2011 approximately 7300 incident cases of cervical cancer will have been averted (versus 2650 to date), and approximately 1145 cervical cancer related deaths will have been prevented (versus 540 to date), as a result of screening (and, in the case of mortality, further improvements in medical treatment of cervical cancer).

[14] These forecasts are based on the target scenario (modelling the squamous series with a hysterectomy-adjusted population), where we assume that period effects are halfway between the optimal and BAU scenarios.

Figure 39: Projected cumulative number of cervical cancer cases averted by 2011

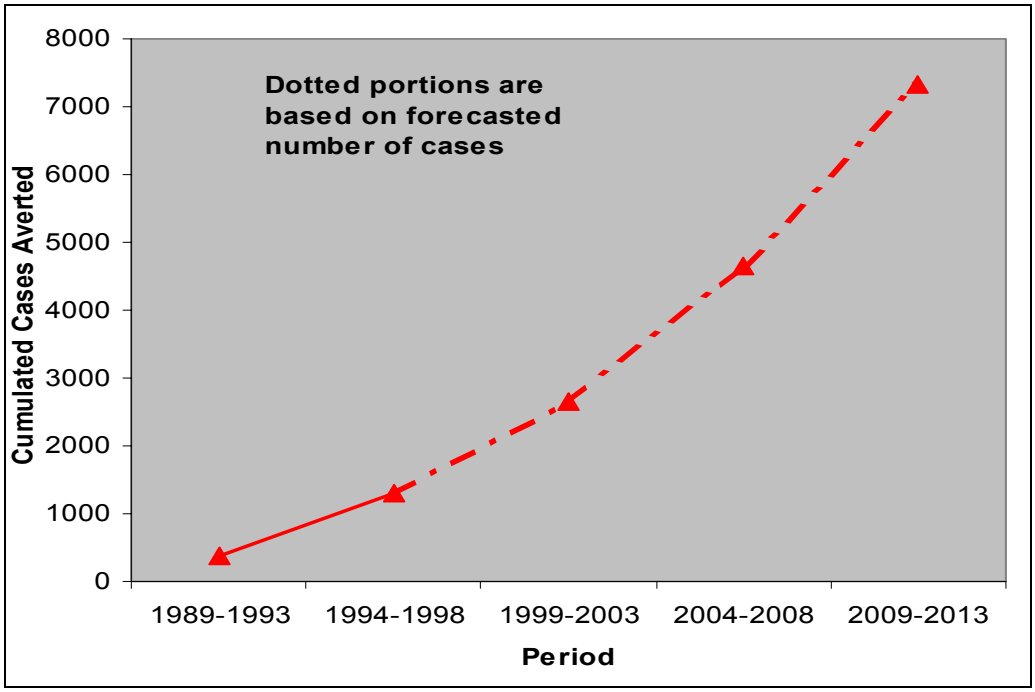
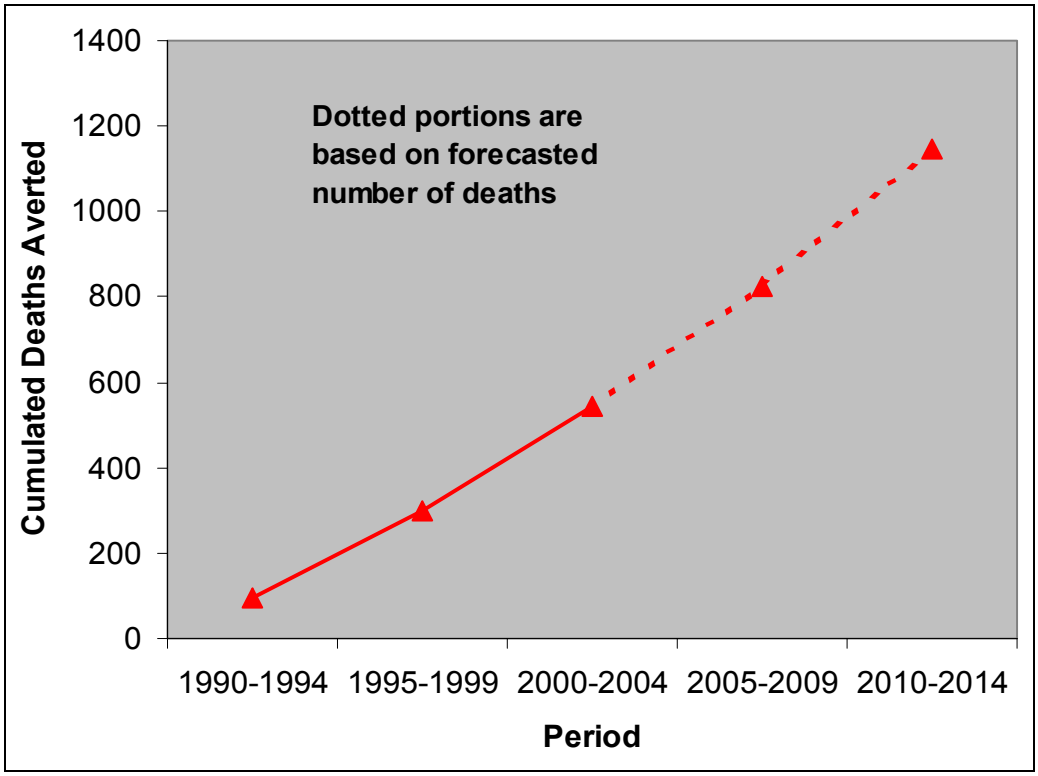


Figure 40: Projected cumulative number of cervical cancer deaths averted by 2011



Assessment of progress toward targets and resetting of targets

In this report we have provided the NCSP with recommended targets based purely on epidemiological and statistical criteria. The targets finally set by the NCSP may involve consideration of a wider set of criteria, and may differ from those recommended here.

Whatever the final targets set, data from the Cancer Registry will allow progress towards them to be monitored on an annual basis. Cumulative programme benefit can also be updated annually.

The targets should be reset at regular intervals, preferably five yearly to coincide with new censal population estimates. This will allow account to be taken of changing trends, while also updating the population projections and the ethnic undercount adjusters.

While targets have been set here for both one and two (five-year) projected periods, it may be preferable in future to set only targets for 10 years out, with a mid-course correction after five years.

Finally, our model does not explicitly relate programme outcomes to process variables. More detailed modelling may be worthwhile to link cervical cancer outcomes (incidence, mortality and survival) to programme performance measures (eg, indicators relating to inputs and intermediate or process variables such as various dimensions of coverage and quality).

Summary of key outcome targets

For ease of reference, a tabular summary of the proposed 'key' targets (ie, those for squamous cervical cancer, based on the hysterectomy-adjusted population) are provided at the end of both the Executive Summary (page xiii) and the main report (Appendix 5, page 72).

Appendix 5 also expresses the targets as annualised average counts, as well as rates.

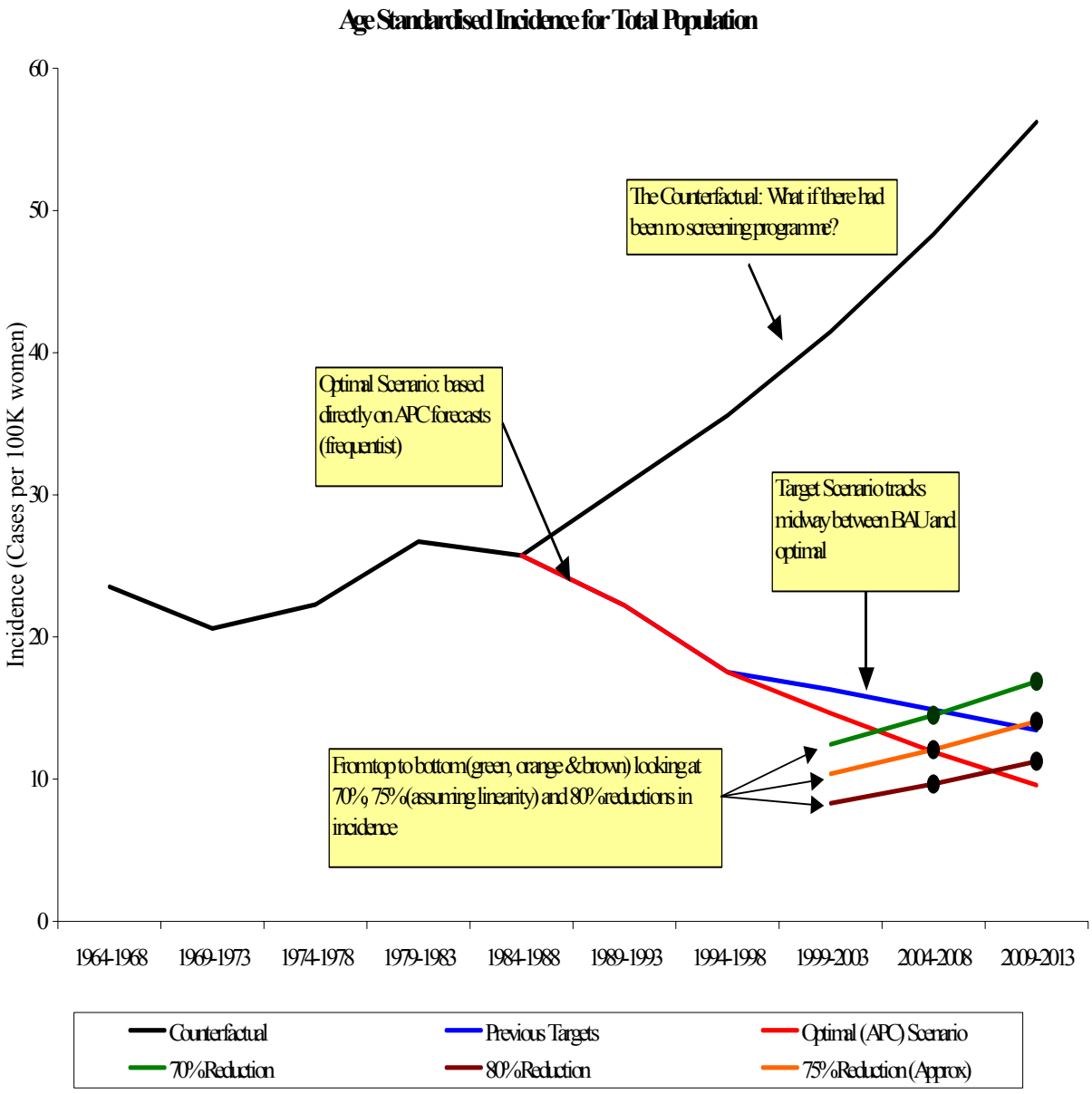
Linking outcome to performance targets

Having modelled the counterfactual (what would happen without screening), it becomes possible to ask what reduction in incidence could theoretically be achieved at any future time, given specified changes in programme coverage and quality. The best evidence we have is that a programme based on a three yearly screening frequency could achieve up to a 90% reduction in incidence, given 100% coverage and the highest achievable technical quality (Paul et al 1991).

Current coverage (hysterectomy adjusted) is estimated to be about 70-75% overall, and a realistic target might be 85-90%. This would correspond to a reduction in cancer incidence from the counterfactual of approximately 75-80% (0.9 x 0.85 or 0.9 x 0.9), after expiry of the lag period.

Figure 41 shows that the recommended incidence target (total population, age standardised, squamous, hysterectomy adjusted) corresponds almost exactly to a 70% reduction from the counterfactual in 2006 and a 75% reduction in 2011. In fact, this is the case for all the recommended incidence targets, including Maori and nonMaori as well as the total population targets (data for ethnic group targets not shown).

Figure 41: Linking outcome to performance targets



Not only does this analysis support the validity of the outcome targets obtained by age/period/cohort modelling (without reference to estimates of programme performance), but it allows the outcome targets to be related to levels of programme performance.

That is, reaching the recommended incidence (and hence, mortality) targets by 2011 will require the achievement of at least 85% coverage overall, together with the highest standards of technical performance at each stage along the screening pathway from smeartaking to colposcopy.

Note, however, that this analysis depends on the accuracy of the counterfactual. We may have over-estimated the projected increase in the counterfactual because opportunistic screening may have elevated the incidence of micro-invasive cancer in recent periods, so inflating the projected incidence rates.

On the other hand, use of five year periods may have led us to underestimate the current rate of decline in incidence.

Both of these factors would result in more conservative targets, especially for incidence but also (to a lesser extent) for mortality. This should be borne in mind when deciding on final targets.

Accepted 'headline' targets

Following completion of the modelling reported here, the NCSP undertook a round of consultation with its expert advisors (both in New Zealand and internationally) and other stakeholders regarding the proposed targets. In addition, since completion of the modelling, an additional 4 years incidence (1999 – 2003) and mortality (1999 – 2004) data has become available.

Based on the expert feedback and updated data, the NCSP has concluded that:

- Targets for specific cancer types and age groups will be valuable for Programme planning and evaluation, but only all cancer, all age targets will be set for external reporting.
- Ethnic specific targets will not be set for external reporting. This may help to secure greater resources to enhance coverage for Maori women, and also acknowledges that the data necessary to set ethnic specific targets is currently inadequate. The risk of victim-blaming, if Maori women are perceived as 'failing' to meet the challenging target set for them, will need to be managed carefully.

- Targets will be expressed only as age standardised rates for females of all ages, with Segi as the standard population, for consistency with previous targets and for international comparability.
- For the same reasons, incidence and mortality targets will not be hysterectomy adjusted, although coverage targets will be.
- Incidence and mortality targets will be set 60% toward the optimal scenario, rather than halfway between business as usual and optimal scenarios. These slightly more challenging targets reflect the faster than expected rates of improvement in both parameters over the past 4 years. Coverage targets are amended accordingly.

The accepted 'headline' targets are shown in table 24.

Table 24: Accepted 'headline' targets, 2006 and 2011

	2006 (2004 – 2008)	**2011 (2009 – 2013)**
Incidence	8.0	7.5
Mortality	2.5	2.0
Coverage (%)	75	80

Note: Incidence and mortality rates are for all cervical cancer per 100 000 females (all ages, all ethnic groups) standardised to Segi's and not hysterectomy adjusted. Coverage rates are for eligible women (age 20 – 69, nonhysterectomised)

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Appendix 1:

Estimated Age, Period and Cohort Effects for Incidence

In the following plots all effects are expressed in exponential terms (ie, they have been 'unlogged') to make the results more interpretable.

Age effects are expressed as age-specific incidence rates (cases per 100,000 person years), while the period and cohort effects can be interpreted as relative risk ratios adjusting for birth cohort or period of diagnosis respectively.

Also note that the age and cohort effects are identical for the optimal, BAU and target scenarios. It is the period effect that distinguishes the scenarios.

Under the counterfactual scenario, we see an increasing period effect over time, whereas under the target and optimal scenarios the period effect declines due to the contribution of screening in reducing cervical cancer incidence.

Figure 41: Age, period and cohort effects (incidence): all cervical cancers (denominator-unadjusted)

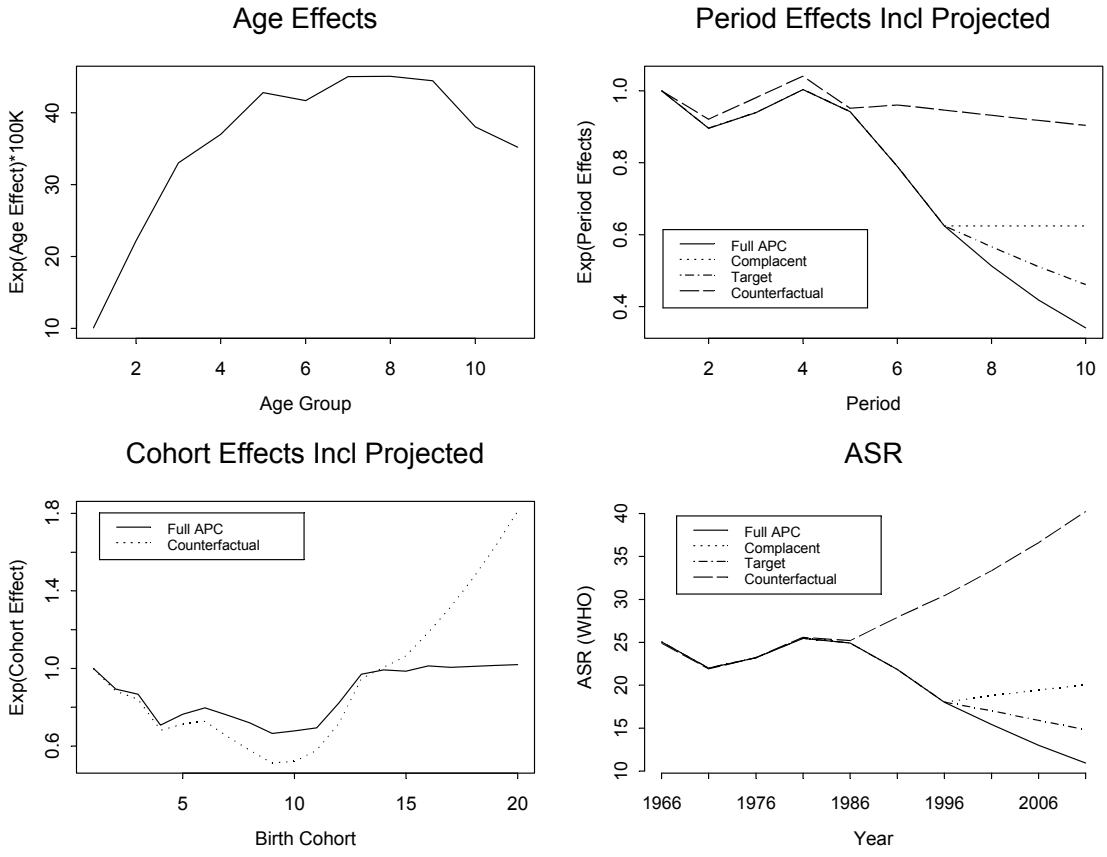


Figure 42: Age, period and cohort effects (incidence): all cervical cancers (denominator hysterectomy-adjusted)

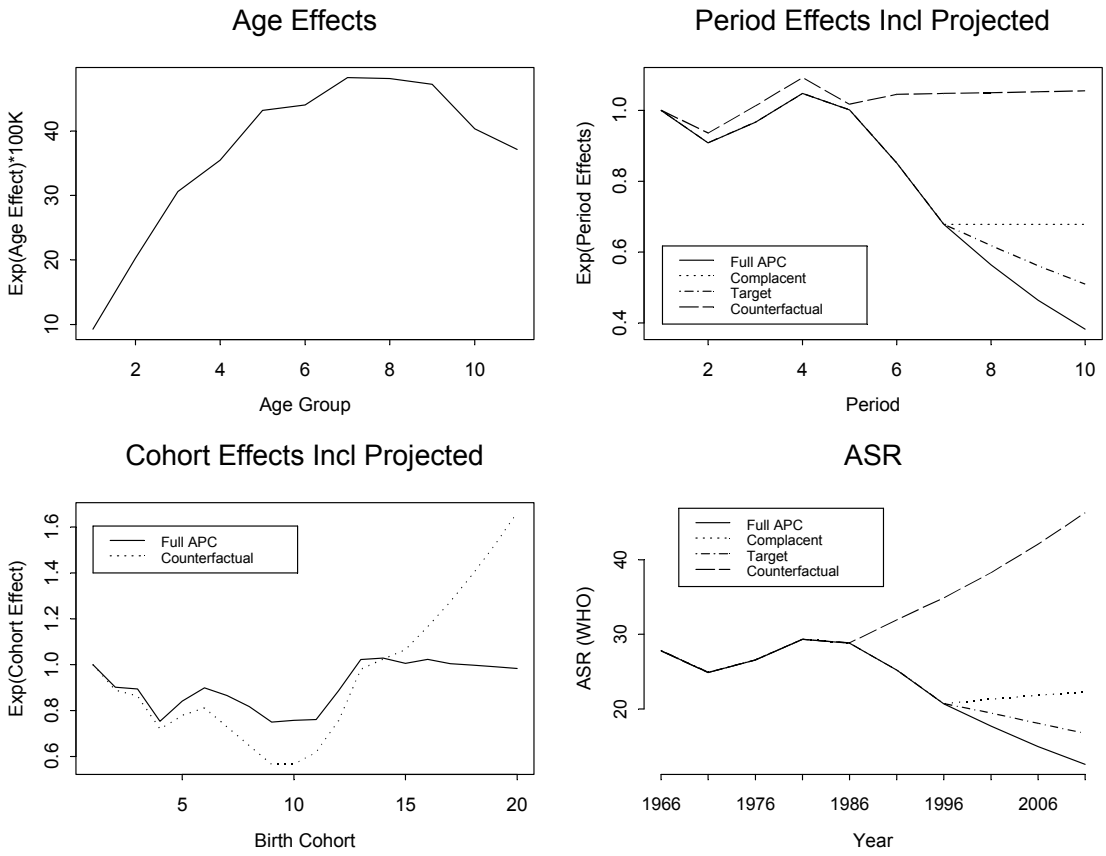


Figure 43: Age, period and cohort effects (incidence): squamous cancers (denominator-unadjusted)

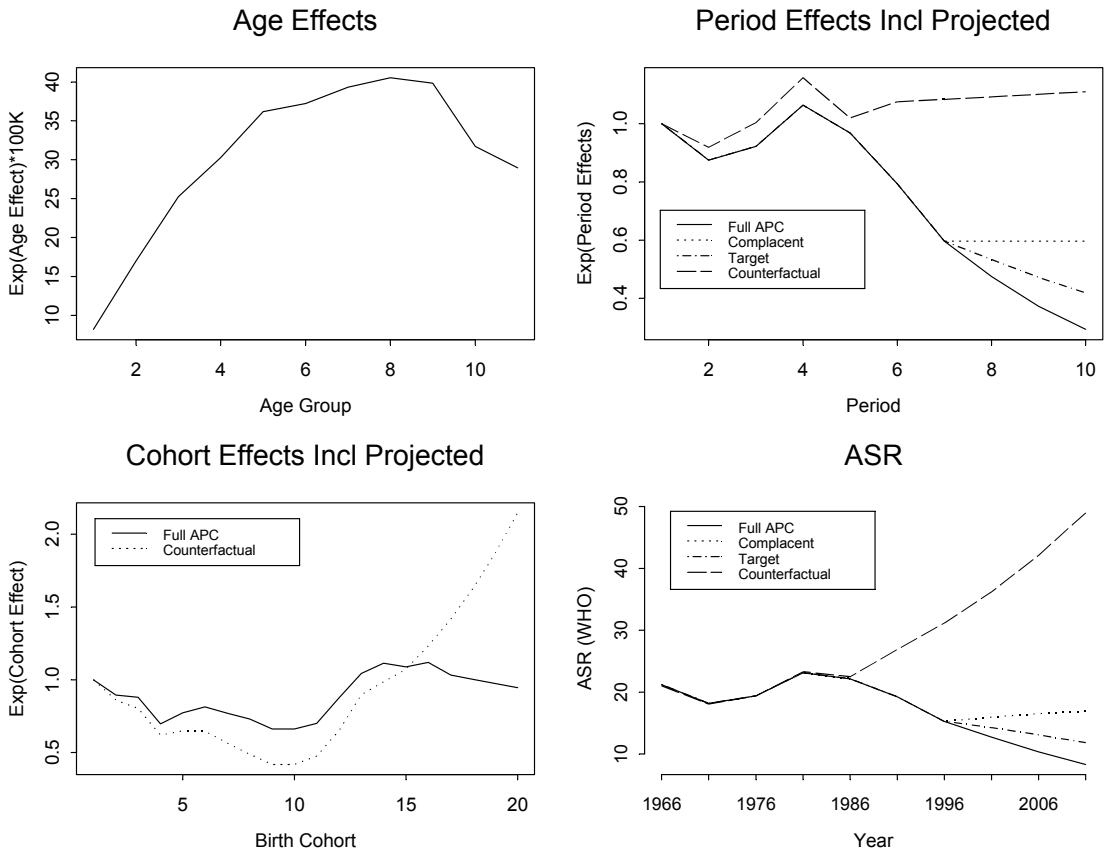
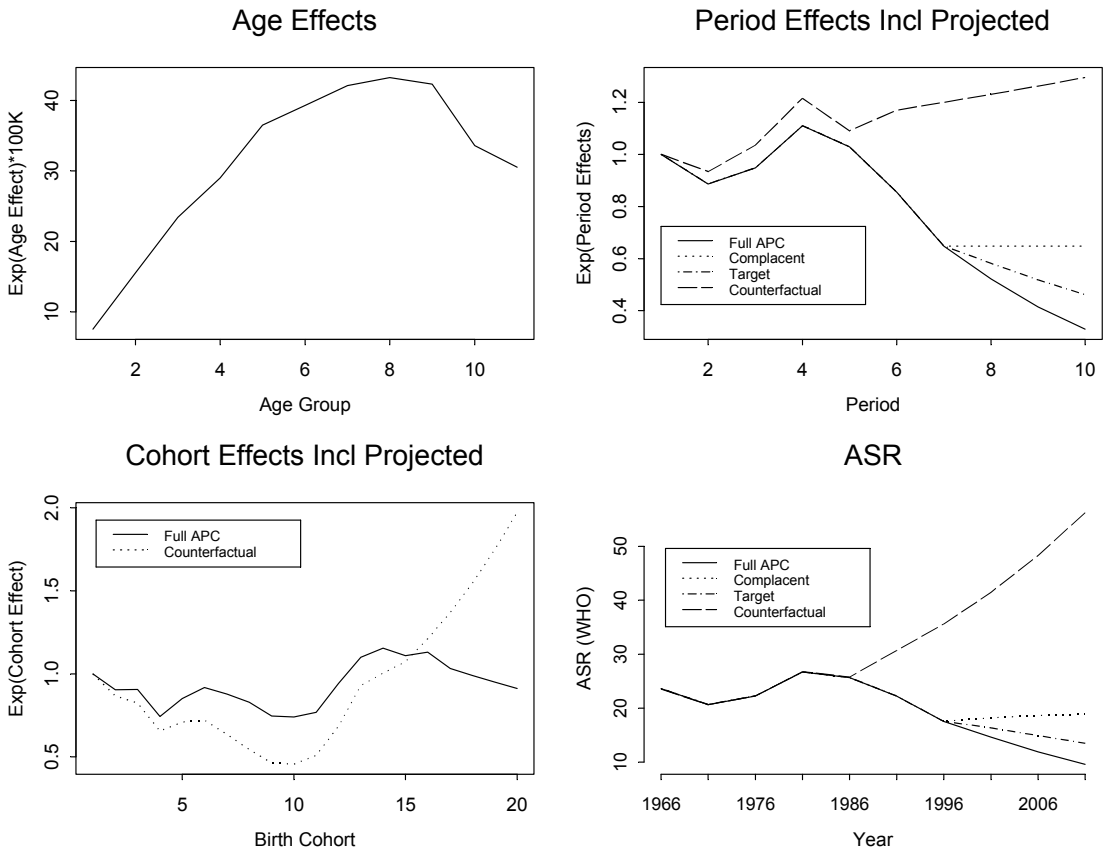


Figure 44: Age, period and cohort effects: squamous cancers (denominator hysterectomy-adjusted)



Appendix 2:

Estimated Age, Period and Cohort Effects for Mortality

Age-effects are expressed as an age-specific rate. The period and cohort effects can be interpreted as relative risk ratios, adjusting for birth cohort and period of diagnosis, respectively.

The shape of the age effects curve is somewhat different for the mortality than for the incidence data. Also, the period effect declines under all scenarios. The rate of decrease under the counterfactual scenario, however, is much lower than in the optimal scenario.

The cohort effects show a prominent peak for women born in the late 1930s to mid-1940s, and therefore most sexually active during the 1960s. This peaking is less apparent in the time series of cohort effects for incidence.

Figure 45: Age, period and cohort effects (mortality): all cervical cancers (denominator-unadjusted)

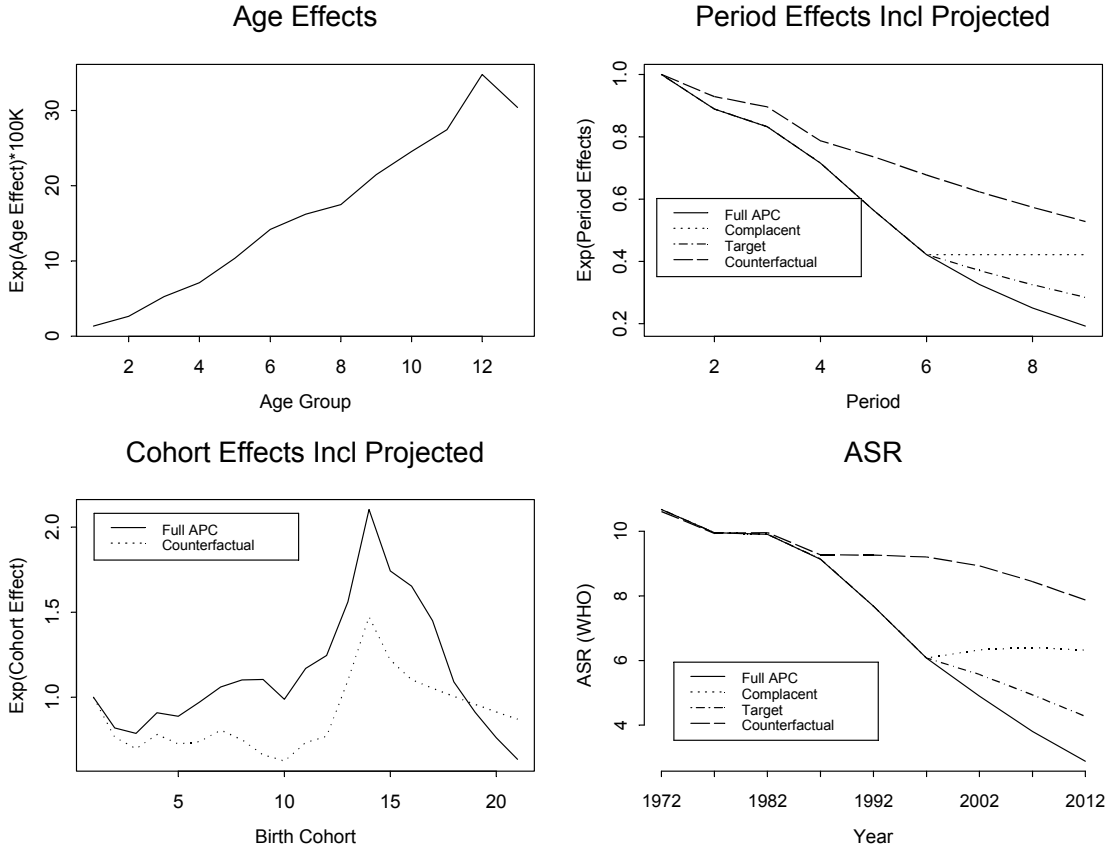


Figure 46: Age, period and cohort effects (mortality): all cervical cancers (denominator hysterectomy-adjusted)

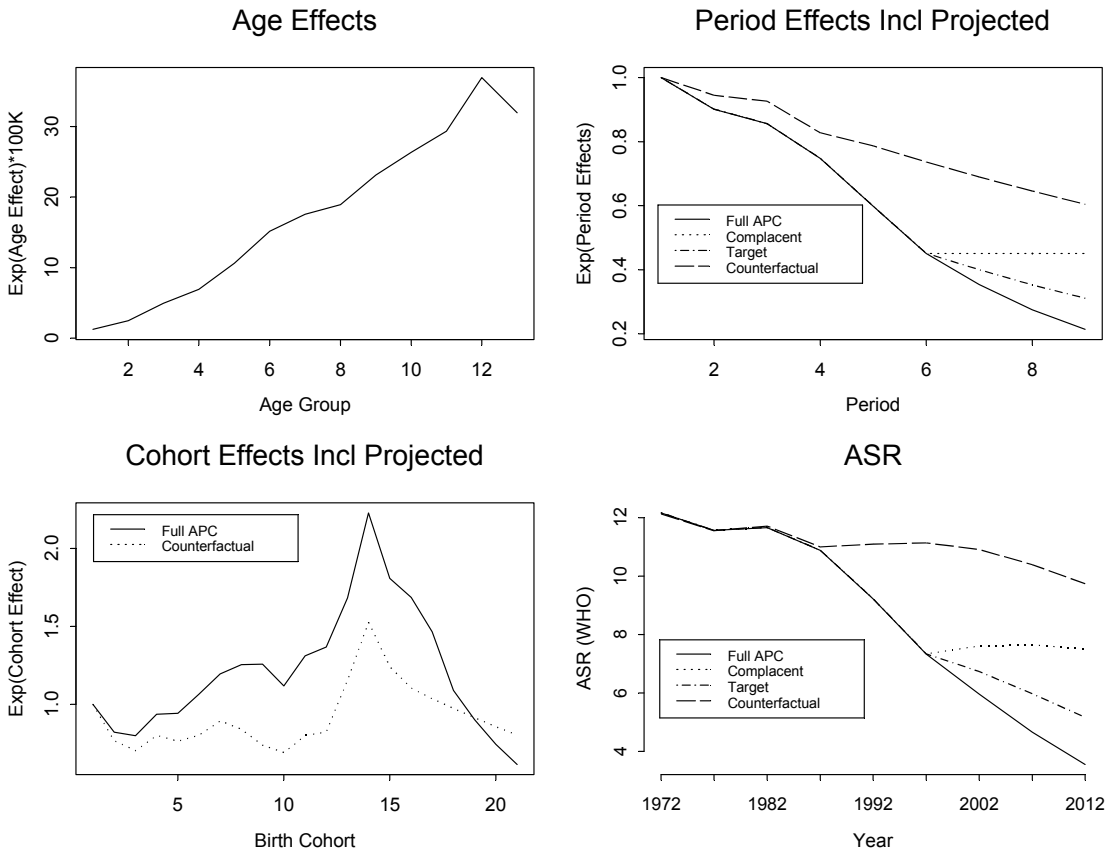


Figure 47: Age, period and cohort effects (mortality): squamous cancers (denominator-unadjusted)

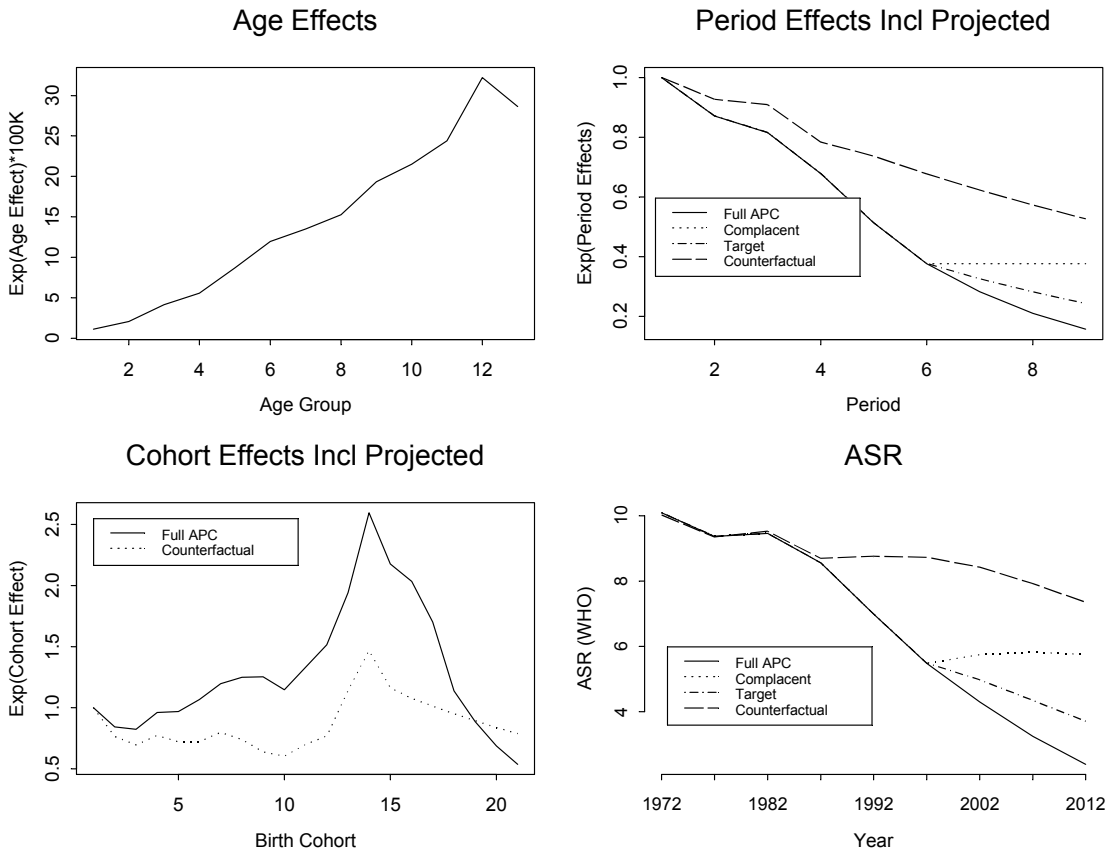
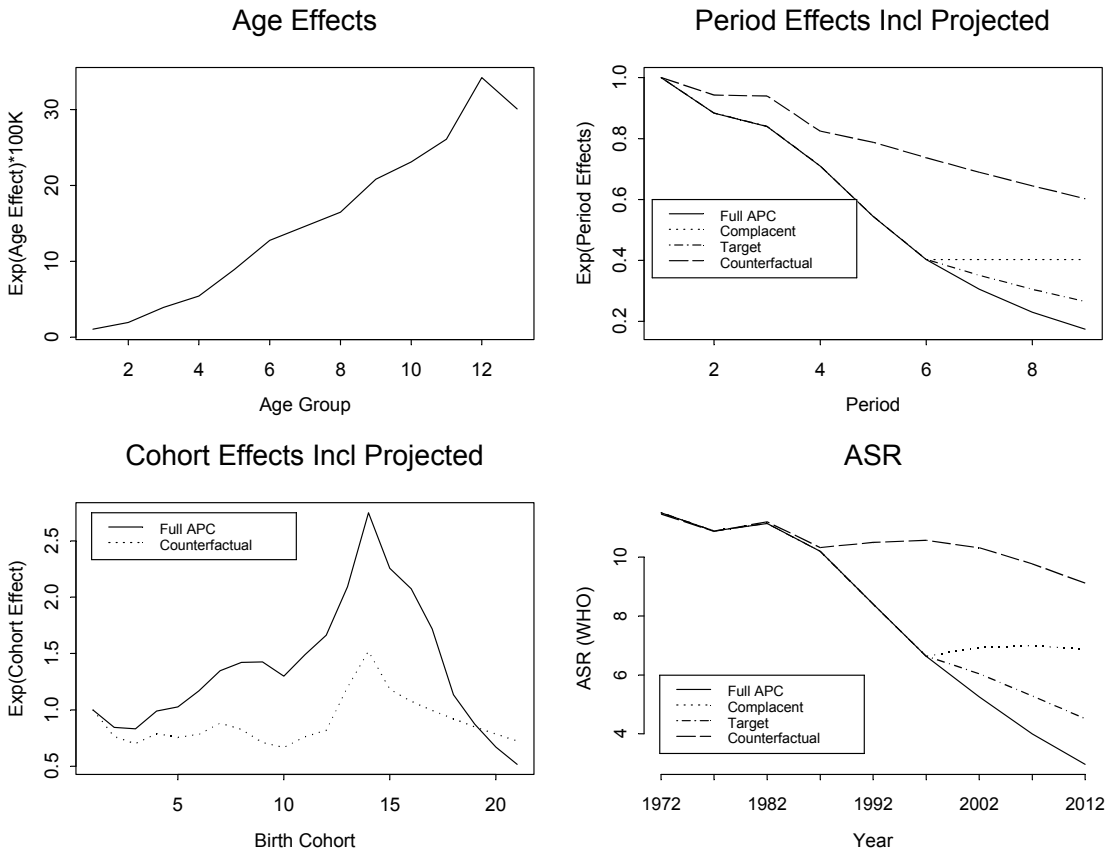


Figure 48: Age, period and cohort effects (mortality): squamous cancers (denominator hysterectomy-adjusted)



Appendix 3:

Hysterectomy Prevalence

The hysterectomy-adjusted population was estimated by modelling hysterectomy prevalence in New Zealand women between 1964 and 1999. Hysterectomy-adjusted population projections were based on the 2001 census population.

We determined New Zealand hysterectomy procedure incidence by extracting public and private hospital discharges for any patient who had an ICD-9 code in the range 683-687, 689. For public hospitals we had discharges from 1978–2002[15] and for private hospitals we had discharges from 1980–95. We also extracted age in years at discharge and year of discharge.

To estimate the periods 1978–79 and 1996–2002 for private hospital hysterectomy procedure discharges, we extrapolated the trend for the total discharges for these years based on the existing private data for the closest five years and then allocated proportionately to five-year age categories based on the distribution of these closest years.

For remoter historical periods, we assumed no incidence of hysterectomy prior to 1900, a gradual increase until 1941 to about 10 percent of the current incidence, and then a linear increase until 1956, to the levels provided by historical hysterectomy data.

We then used central estimates of survival and hysterectomy incidence by five-year age groups and five-year periods to generate a life table of survival of women having had a hysterectomy to determine the prevalence in any given age group and period.

The incidence data was also modelled using a binomial regression adjusting for age, year, and ICD coding system. The model provided a poor fit to the data, and when used to calculate the hysterectomy prevalence, produced differences of about 0.5 percent from that produced by the historical incidence data.

Modelled hysterectomy prevalence estimates (by five-year period and five-year age group) are summarised in the tables below.

[15] 2002 discharges for January to June.

Table 25: Hysterectomy prevalence 1954–2013 for all New Zealand women

	1954–58 %	1959–63 %	1964–68 %	1969–73 %	1974–78 %	1979–83 %	1984–88 %	1989–93 %	1994–98 %	1999–03 %	2004–08 %	2009–13 %
25–29	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
30–34	0.9	1.1	1.2	1.2	1.2	1.2	1.5	1.0	0.7	0.5	0.4	0.4
35–39	3.2	4.2	4.5	4.6	4.6	4.6	5.2	4.4	2.9	2.1	1.7	1.6
40–44	6.2	8.4	9.4	9.8	9.9	9.9	10.5	10.2	8.3	5.8	4.5	4.2
45–49	9.0	12.7	14.9	16.0	16.3	16.4	16.4	16.4	15.2	12.9	10.4	9.1
50–54	9.5	14.2	17.8	20.0	20.9	21.3	21.7	21.3	21.1	19.7	17.3	14.8
55–59	7.5	12.1	16.7	20.3	22.3	23.3	23.8	24.1	23.7	23.6	22.2	19.9
60–64	5.0	8.6	13.2	17.8	21.3	23.3	24.3	24.9	25.2	25.0	24.9	23.6
65–69	3.5	6.0	9.6	14.2	18.7	22.2	24.2	25.2	25.9	26.3	26.0	26.0
70–74	2.9	4.7	7.2	10.8	15.2	19.7	23.1	25.2	26.4	26.9	27.5	27.3
75–79	2.6	4.0	5.8	8.2	11.8	16.2	20.6	24.0	26.2	27.4	28.0	28.6
80–84	2.0	3.4	4.8	6.5	9.0	12.5	16.9	21.2	24.8	26.9	28.2	28.8
85+	1.4	2.5	3.8	5.2	7.0	9.4	12.9	17.3	21.7	25.3	27.4	28.8

Table 26: Hysterectomy prevalence 1954–2013 for Māori women

	1954–58 %	1959–63 %	1964–68 %	1969–73 %	1974–78 %	1979–83 %	1984–88 %	1989–93 %	1994–98 %	1999–03 %	2004–08 %	2009–13 %
25–29	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.1	0.1	0.0	0.1	0.0
30–34	1.5	2.0	2.2	2.2	2.3	2.3	2.3	1.6	0.5	0.4	0.2	0.2
35–39	2.9	4.1	4.7	4.9	5.0	5.0	5.1	4.6	2.9	1.5	0.9	0.6
40–44	6.1	8.4	9.6	10.4	10.5	10.7	10.8	10.3	8.1	5.1	2.8	2.2
45–49	8.4	12.1	14.4	15.8	16.5	16.7	17.0	16.1	14.5	11.5	7.2	4.9
50–54	9.4	14.0	17.7	20.0	21.3	22.0	22.3	22.4	20.3	17.4	13.3	9.1
55–59	6.7	11.2	15.7	19.4	21.7	23.0	23.7	24.4	23.9	21.6	18.3	14.3
60–64	4.1	7.3	11.8	16.3	20.0	22.3	23.6	24.3	24.9	24.5	22.0	18.8
65–69	3.3	5.4	8.6	13.1	17.5	21.2	23.5	24.2	24.8	25.3	24.9	22.4
70–74	2.2	3.6	5.7	8.9	13.4	17.8	21.4	24.0	24.8	25.3	25.7	25.2
75–79	1.4	2.4	3.9	5.9	9.1	13.6	18.0	21.8	24.6	25.1	25.6	26.0
80–84	0.9	1.6	2.6	4.1	6.1	9.3	13.8	18.3	22.1	24.9	25.3	25.8
85+	0.4	0.9	1.6	2.6	4.1	6.1	9.3	13.8	18.3	22.1	24.9	25.3

Appendix 4:

Modelling Ethnic-specific Cases and Deaths

Modelling Māori cases and deaths

In order to derive estimates of the Māori proportions mentioned above, we first need reliable estimates of the number of cervical cancer cases (or deaths) over the 1991–99 period that were Māori-specific. Given the undercounting of Māori populations, this in itself is problematic.

To handle the issue of undercounting Māori cervical cancer cases, we developed an 'ever-Māori' ethnicity adjuster. The adjuster was developed using hospitalisation records. If the hospitalisation record of any 'case' was ever recorded as Māori, then that case was immediately classified as Māori.

In the case of Māori cervical cancer deaths, we used NZCMS ethnicity adjusters (Ajwani et al 2002) to estimate the 'true' number of Māori cervical cancer deaths.

Figures 49 and 50 show the estimated Māori proportion of cervical cancer cases and deaths by age group respectively. Note that these proportions are derived by averaging the age-specific Māori proportions over the periods 1991–99. In other words, the proportion of Māori specific cases (or deaths) in age group a is given by the following formula:

$$\pi_a^{(\text{Cases/Deaths})} = \frac{1}{10}\sum_{p\in[1991,1999]} \frac{\text{cases}_{a,p}^{(\text{Maori})}}{\text{cases}_{a,p}^{(\text{total})}}$$

Also note that we have not modelled the percentage of Māori specific squamous cervical cancer cases (deaths) separately. Instead, we assume that this percentage is constant, irrespective of the type of cervical cancer.

Figure 49: Age-specific proportion of Māori cervical cases (obtained by averaging over periods 1991–99)

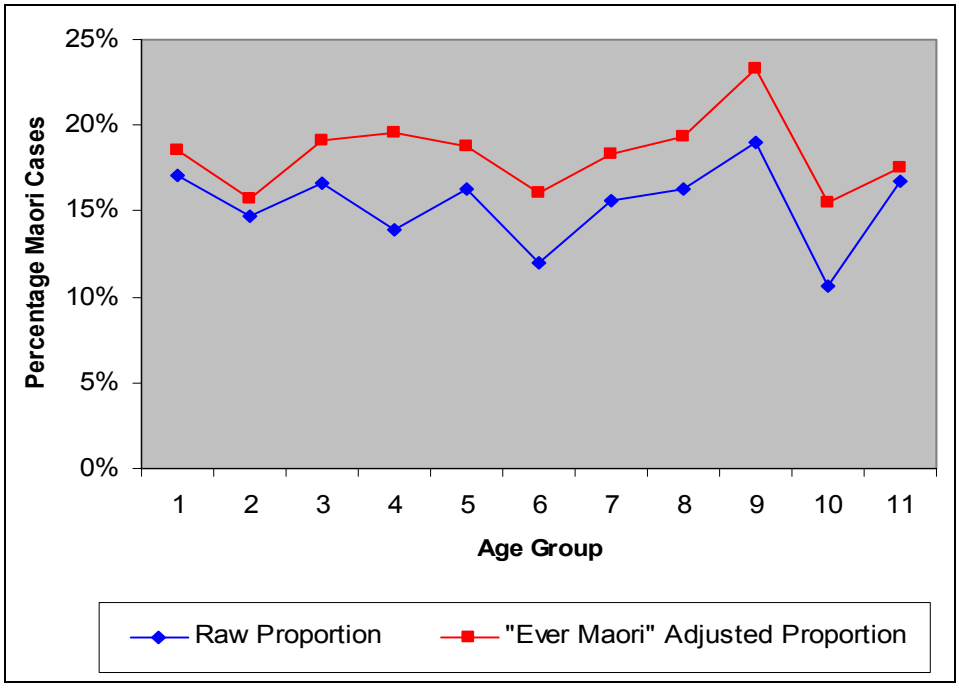
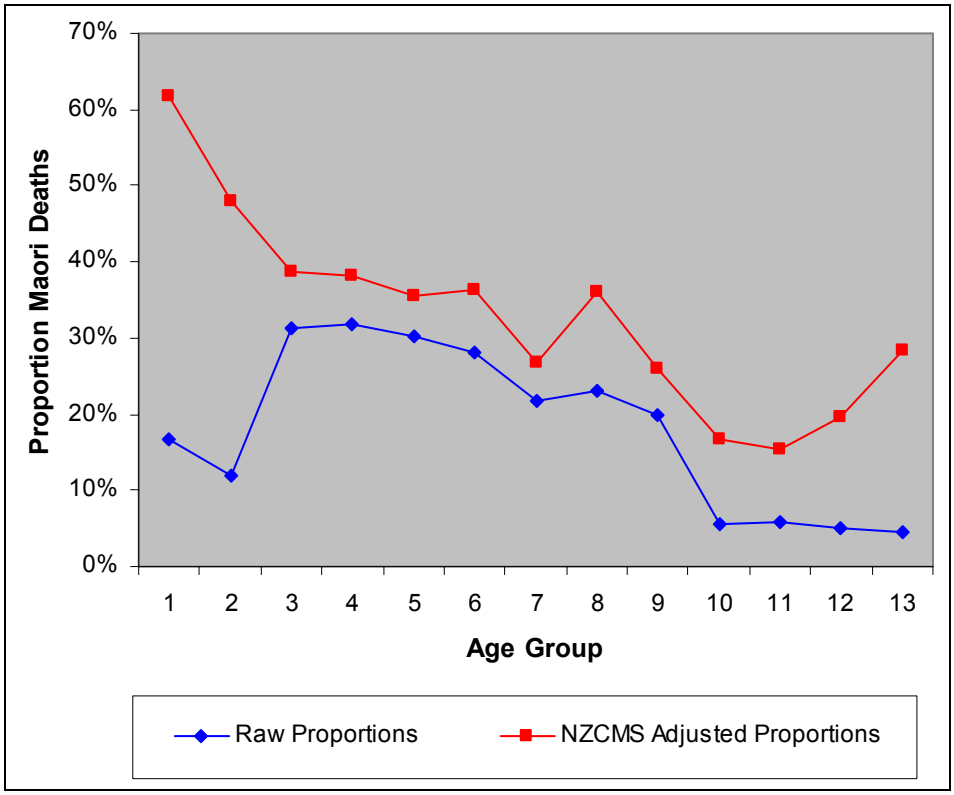


Figure 50: Age-specific proportion of Māori cervical deaths (obtained by averaging over periods 1991–99)



Given the proportions in Figures 49 and 50, the Māori incidence target for age group *a* in 2005, can be derived as follows:

$$r_{a,\text{Maori}} = \frac{\text{cases}_{\text{a,total}} \times \pi_a^{(\text{Cases})}}{\text{person years}_{\text{a,Maori}}}.$$

Similarly, the Māori mortality target for age group *a* in 2005, can be derived as follows:

$$m_{a,\text{Maori}} = \frac{\text{deaths}_{\text{a,total}} \times \pi_a^{(\text{Deaths})}}{\text{person years}_{\text{a,Maori}}}.$$

Modelling non-Māori cases and deaths

Non-Māori cases and deaths (used to derive non-Māori specific targets) are modelled in a similar manner, using one minus the estimated Māori proportion. Figures 51 and 52 show the estimated proportion of non-Māori specific cervical cancer cases and deaths, respectively.

Figure 51: Age-specific proportion of non-Māori cervical cases (1 minus Māori proportion)

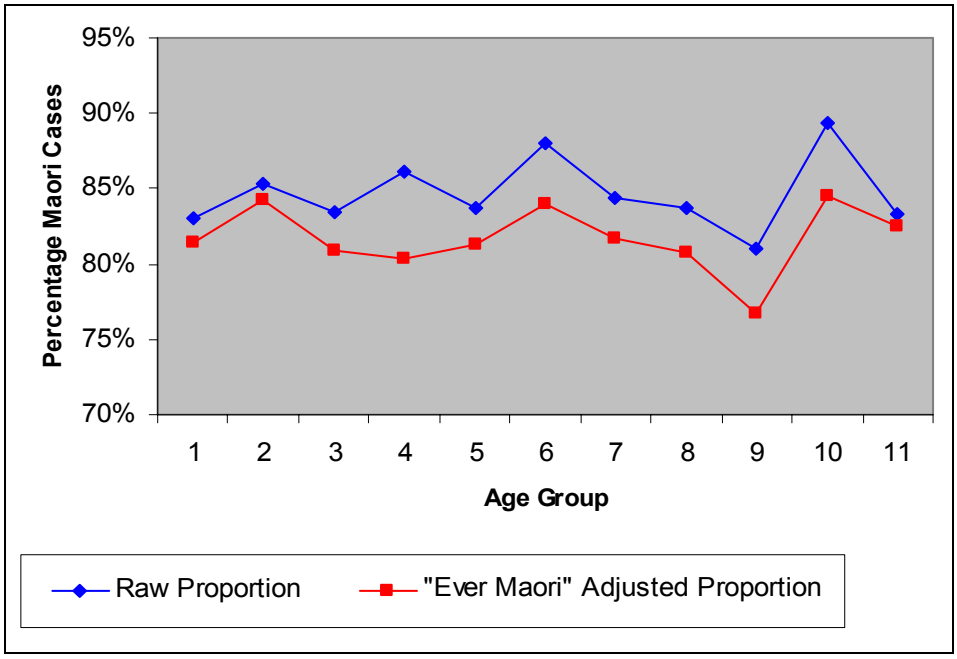
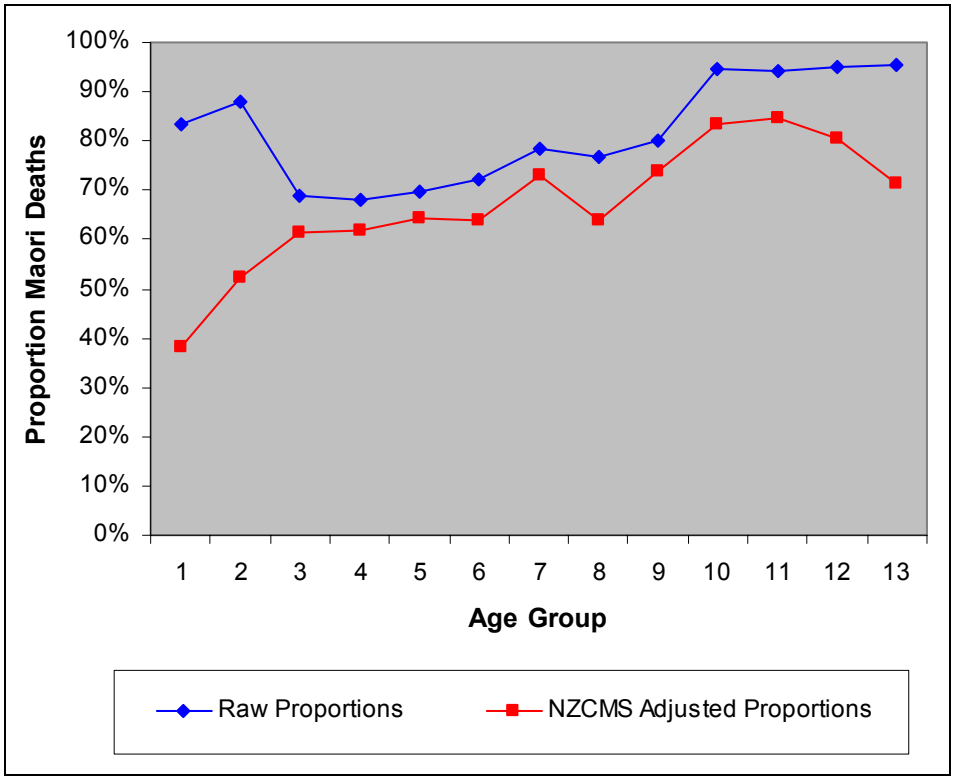


Figure 52: Age-specific proportion of non-Māori cervical deaths (1 minus Māori proportion)



Appendix 5: Key Targets Expressed as Rates and Counts

Rates

The 'key' target rates (derived for squamous cervical cancer for a hysterectomy-adjusted population) are summarised in Tables 25–26 below.

Counts

Throughout this report we have presented targets in terms of incidence and mortality rates. From a policy perspective, however, it may be useful to also monitor targets in terms of the number of cervical cancer cases or related deaths. To this end we present target counts as well as rates in this appendix (ie, we multiply the target incidence and mortality rates by the appropriate person-years denominator).

We present here only counts for the 'key' targets (ie, squamous cervical cancer, based on a hysterectomy-adjusted population).

Note that counts have been annualised (ie, the count for 2006 represents the average for the 2004–08 period (incidence) or 2005–09 period (mortality), and similarly for 2011).

Also note that in some cases the number of Māori and non-Māori cases (or deaths) exceeds the total number of cases (or deaths) by one. This discrepancy can be attributed to rounding error introduced in the annualisation of counts over a five-year period.

Note that the counts are annualised averages, intended to provide an *indication* of what the target rates might mean, rather than being themselves precise targets for which to aim.

The results are summarised in Tables 27–29. Note that the expected counts do not generally decrease from 2006 to 20011, despite the projected decline in the corresponding rates. This is because the projected fall in the risk of cervical cancer incidence or mortality is offset by demographic trends, mainly the anticipated increase in population size and (to a lesser extent) changes in population age structure.

Table 27: Key incidence and mortality targets (squamous series, hysterectomy-adjusted) expressed as age-standardised rates

	Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
Total population	**14.9**	**13.5**	**5.3**	**4.5**
	(7.9)	(7.1)	(2.8)	(2.4)
Māori	**25.5**	**21.8**	**18.1**	**13.7**
	(13.5)	(11.5)	(9.5)	(7.2)
Non-Māori	**13.8**	**12.6**	**4.2**	**3.7**
	(7.3)	(6.7)	(2.2)	(1.9)

Note: Rates in bold are per 100,000 women aged 25–79 years for incidence and 25+ years for mortality, standardised to WHO world population. Rates in (parentheses) are per 100,000 females aged 0–100+, standardised to Segi population.

Table 28: Key incidence and mortality targets (squamous series, hysterectomy-adjusted) expressed as age-specific rates

		Incidence 2006	Incidence 2011	Mortality 2006	Mortality 2011
25–34	Total	5.9	5.0	0.4	0.2
	Maori	5.8	4.9	0.4	0.0
	Non-Maori	6.0	5.0	0.4	0.3
35–44	Total	14.8	12.3	2.1	1.2
	Maori	20.1	16.5	6.8	3.7
	Non-Maori	14.0	11.8	1.4	0.8
45–54	Total	22.1	19.6	7.0	5.5
	Maori	33.0	27.4	26.1	16.8
	Non-Maori	21.0	19.0	5.1	4.1
55–64	Total	22.7	22.2	11.6	10.3
	Maori	48.0	41.0	47.8	38.7
	Non-Maori	20.0	19.6	8.9	7.9
65–74	Total	14.9	15.4	10.4	11.1
	Maori	40.3	40.9	27.9	27.1
	Non-Maori	12.7	13.0	9.3	10.0
75+	Total	3	2.5	12.6	11.0
	Maori	23.4	16.8	29.6	22.4
	Non-Maori	4.1	3.3	12.1	10.6

Note: Rates are per 100,000 women.

Table 29: Key incidence and mortality targets expressed as counts, total population (squamous series, hysterectomy-adjusted)

	Squamous cervical cancer incident cases target		Squamous cervical cancer-related deaths target	
	2006	**2011**	**2006**	**2011**
<45	62	50	8	4
45–64	94	100	38	36
65+	21	23	25	27
Total	177	173	71	67

Table 30: Key incidence and mortality targets expressed as counts, Māori population (squamous series, hysterectomy-adjusted)

	Squamous cervical cancer incident cases target		Squamous cervical cancer-related deaths target	
	2006	**2011**	**2006**	**2011**
<45	12	9	3	2
45–64	17	18	12	11
65+	4	5	3	3
Total	33	32	18	16

Table 31: Key incidence and mortality targets expressed as counts, non-Māori population (squamous series, hysterectomy-adjusted)

	Squamous cervical cancer incident cases target		Squamous cervical cancer-related deaths target	
	2006	**2011**	**2006**	**2011**
<45	51	51	5	3
45–64	77	77	26	25
65+	17	17	22	26
Total	145	145	53	54