Travel time and distance to health care only partially account for the ethnic inequalities in cervical cancer stage at diagnosis and mortality in New Zealand

Naomi Brewer
Centre for Public Health Research, Massey University, New Zealand

Neil Pearce
Centre for Public Health Research, Massey University, New Zealand; and Department of Medical Statistics, Faculty of Epidemiology and Public Health, London School of Hygiene and Tropical Medicine, UK

Peter Day
GeoHealth Laboratory, Department of Geography, University of Canterbury, New Zealand

Barry Borman
Centre for Public Health Research, Massey University, New Zealand

Abstract

Objective: To investigate whether travel time or distance to the nearest general practitioner (GP) and/or cancer centre accounts for the ethnic differences in cervical cancer screening, stage at diagnosis and mortality in New Zealand (NZ).

Methods: The study involved 1,594 cervical cancer cases registered between 1994 and 2005. Travel time and distance to the GP and cancer centre were estimated using a Geographical Information System.

Results: Adjustment for travel time or distance made almost no difference to ethnic differences in screening rates. Adjustment for travel time reduced the excess risk for late-stage diagnosis in Māori (the odds ratio (OR) reduced from 2.71 (95%CI 1.98-3.72) to 2.59 (1.88-3.56), a 7% decrease) and 33% in Pacific (the OR reduced from 1.39 (0.76-2.54) to 1.26 (0.68-2.33)) women. Adjustment for travel time reduced the excess risk for mortality by 3% in Māori (the hazard ratio (HR) reduced from 1.59 (1.21-2.08) to 1.57 (1.19-2.06)) and 13% in Pacific (the HR reduced from 1.92 (1.20-3.08) to 1.80 (1.11-2.91)) women. Similar findings were observed when using travel distance rather than travel time.

Conclusions: Travel time and distance are only weakly associated with cervical cancer screening, stage at diagnosis and mortality in NZ. However, travel time may account for a small proportion of the ethnic differences in stage at diagnosis, and to a lesser extent mortality, particularly for Pacific women.

Implications: The findings suggest that there may be ethnic variations in access to treatment or treatment quality, which may be related to travel time.

Key words: Uterine cervical neoplasms, ethnicity, geographical variation, inequalities, New Zealand

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In 2007, cervical cancer was the 13th most common site of cancer registration for New Zealand (NZ) females.[1] Incidence and mortality rates are relatively low compared with the rest of the developed world,[2] but are not the same across ethnic groups within NZ. For example, in 2005, Māori women had an incidence rate of 9.0, Pacific women 16.3 and 'Other' (predominantly European) women 5.6 per 100,000 women; Māori women had a mortality rate of 6.5, Pacific women 7.1 and 'Other' women 1.4 per 100,000 women.[3] In 2007, the age-standardised mortality (standardised to the World Health Organization standard world population) rate was 2.2 per 100,000 women but again varied by ethnicity: 4.5 per 100,000 in Māori women compared with 2.0 in non-Māori women.[1] The difference in the mortality rate between Māori and non-Māori women has fluctuated over the past few years but appears to have decreased to an approximately two-fold difference (unpublished data from the NZ Ministry of Health provided to, and analysed by, the authors).

There are major demographic differences in cervical cancer screening[4] in NZ, and the National Screening Unit therefore has an on-going campaign (see http://www.nsu.govt.nz/current-nsu-programmes/2445.aspx) to increase cervical screening rates particularly in Māori and Pacific women who are currently under screened.[5] There are also major demographic differences in cervical cancer stage at diagnosis[6] and mortality in NZ.[6,7] In previous analyses adjustment for stage at diagnosis, socio-economic position (SEP), and urban/rural residence explained only some of the increased mortality risks in Māori and Pacific women (compared with 'Other' women).[6] Ethnic differences in stage at diagnosis were not entirely explained by differences in screening history.[4] Adjustment for comorbid conditions accounted for a moderate proportion of the ethnic differences in mortality.[8]

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Correspondence to: Dr Naomi Brewer, Centre for Public Health Research, Massey University – Wellington Campus, PO Box 756, Wellington 6140, New Zealand; e-mail: N.Brewer@massey.ac.nz

Thus, the reasons for the ethnic differences in mortality are currently unclear, but one possibility not previously examined is that they may be due to differences in travel time and/or distance to the nearest general practitioner (GP) and/or cancer treatment centre. Travel time and distance could impact on mortality by affecting rates of screening and therefore stage at diagnosis or more directly by affecting access to, or utilisation of, treatment once women have been diagnosed. In NZ, McLeod et al.[9] found that some healthcare providers perceived transportation, including the financial cost of travelling long distances to cancer centres, as well the required time, and the levels of tiredness that patients experience, to be a barrier to accessing treatment, resulting in some women not attending scheduled appointments or refusing treatment altogether.

Internationally, several studies have shown travel distance to, or remoteness from, GP practices and cancer treatment facilities, to have a negative impact on cancer mortality and survival.[10-13] These effects may be mediated through later stage at diagnosis and lower utilisation of health services, possibly because of the higher financial costs and inconvenience.[11] Lack of access to healthcare in rural areas, due to transportation problems or fewer primary healthcare providers and specialist diagnostic and treatment services has been associated with reduced cervical cancer screening and treatment.[14,15] Yabroff et al.[16] suggest that rural physicians are less likely to offer cervical screening compared with their non-rural counterparts. Rural residence has also been shown to be associated with higher mortality rates.[14,16] Travel time and distance, and the associated costs and inconvenience of transportation, have been shown to be a perceived barrier to care[17] and may lead to "patients opting to forgo needed care",[18] especially in ethnic minorities.

However, not all studies internationally[19] or in NZ[6,20-22] have found consistent associations between travel distance or remoteness and cancer stage, mortality and survival. Haynes et al.[22] found no evidence of a later stage at diagnosis in those living furthest from either a cancer centre or a GP. They found poorer survival in prostate cancer patients who had longer travel times to a GP, and for patients with colorectal, breast or prostate cancer who had longer travel times to a cancer centre, but not for lung cancer or melanoma patients. Bennett et al.[20] did not find an association between urban/rural residence and breast cancer stage or survival. Gill and Martin[21] found an inconsistent association between distance from a cancer centre and upper gastrointestinal cancer, with those living 51-100 kilometres (km) away having a worse prognosis than those living >200 km away.

There are geographic and ethnic variations in GP accessibility in NZ. Māori live relatively more in rural areas and therefore have longer travel times to their nearest GP; Pacific people are more urban and have shorter travel times.[23] However, there have been few studies of the effects on cancer survival in NZ.[6,20-22] Furthermore, for cervical cancer (as with breast cancer) there is a national screening programme, and the possibility therefore exists to study screening history. We here investigate whether travel time and/or distance accounts for the previously observed ethnic differences in cervical cancer screening, stage at diagnosis and mortality.

Methods

The source population was all cervical cancer cases registered with the NZ Cancer Registry (NZCR) between 1 January 1994 and 31 December 2005.[4,6] The NZCR records self-identified ethnicity. Participants who reported more than one ethnicity were classified into a single ethnicity using the standard system of prioritisation: Māori > Pacific > Asian > 'Other'.[24] The latter category includes participants with missing ethnicity data. This approach is standard practice in NZ health research.[25,26] All registrations include the unique National Health Index (NHI) number; this was used to obtain cause-specific mortality data (from the Mortality Collection) up to the end of December 2005 (the most recent year for which data was available), and to obtain the woman's cervical screening history from the National Cervical Screening Programme (NCSP) Register.

The classifications of screening history were based on those used for the New Zealand Cervical Cancer audit[27] and for quality monitoring by the NCSP.[28] Women were categorised as 'not screened' or 'ever screened'. We excluded smears taken in the six months immediately prior to diagnosis since some of these will have been taken for diagnostic, not screening, purposes.[29,30] The full details of the categorisation have been described elsewhere.[4] Cervical screening guidelines are extremely complex,[31] and the categories used in this study are only able to approximate the women's screening histories.[27]

SEP was estimated using the New Zealand Deprivation Index 2001 (NZDep), an area-based measure derived from the national census.[32] Each participant was assigned a score based on the residential area (domicile code) in which they lived, as recorded at registration on the NZCR. These scores were then grouped into quintiles.[32]

Data on stage at diagnosis were obtained from the NZCR, and reported using the International Federation of Gynecology and Obstetrics (FIGO)[33] system. In order to provide sufficient numbers in each category, the FIGO stages were grouped into four categories: stages 0-IB2; II-IIB; III-IIIB; IVA-IVB. The FIGO stages were also further grouped into early stage (FIGO stages 0-IB2) and late stage (FIGO stages II-IVB) for some analyses. Women with an unknown stage at diagnosis, or who could not be allocated a deprivation score, were excluded from the analyses. We conducted a sensitivity analysis to assess the potential for bias resulting from the exclusion of these women that showed that the study findings were generally similar whether these women were included or excluded; we have therefore excluded them because it is necessary to adjust for stage, and this is the only approach which enables us to do this validly.[8] There was little ethnic or socioeconomic difference in the percentage of cases with missing FIGO codes.[4]

The methods used to estimate travel time and distance to the nearest GP and cancer centre were based on those of Haynes et al.[22] and Pearce et al.[34] The domicile code recorded for each participant was matched to a 2001 Census Area Unit (CAU), allowing a location to be assigned to each participant. The travel time (in minutes, and proportions of minutes) and distance (in metres) to the nearest GP surgery (n=1,383) and to the nearest of the six cancer centres were

calculated from the population weighted centroids of each of the 1,860 CAUs across NZ, using the road network functionality in a Geographical Information System.[22] These were then categorised according to the method of Haynes et al:[22] Low – the lowest quartile; Medium – quartiles two and three; High – records between the 75 and 95 percentiles; Highest – the highest 5% of records. "The reason for dividing the fourth quartile into categories 3 and 4 was to distinguish the most extreme values of journey times ... where the greatest effect might be expected".[22]

All analyses were conducted using Intercooled Stata 11.1 for Windows (StataCorp, College Station, Texas, US). Logistic regression was used to estimate the associations with stage at diagnosis. Cox regression was used to estimate adjusted cervical cancer mortality hazard ratios (HRs). All analyses were adjusted for ethnicity, age, registration year and SEP. In general, the findings were similar for travel time and distance, but these were strongly correlated with each other, and were therefore not included in the models at the same time, because of potential problems of multicollinearity.

The New Zealand Central Ethics Committee granted ethical approval for the study (CEN/08/04/EXP).

Results

There were 2,323 cases of cervical cancer registered on the NZCR between 1 January 1994 and 31 December 2005. The following exclusions were made: 17 women because their cancer registration was made on the date of the woman's death, 126 because they did not have a domicile code that could be assigned an NZDep score or used to estimate their travel time and distance, 555 because they did not have a FIGO code, and a further 31 because they were diagnosed after 30 June 2005 (and therefore had a potential follow-up time of less than six months). This left 1,594 women to be included in the analyses. Of these: 99.2% were diagnosed based upon the histology of the primary malignant tumour;[6] 1,163 (73%) identified as 'Other' ethnicity, 312 of whom died during the follow-up period, 241 (77%) due to cervical cancer, and 71 (23%) due to other causes; 292 identified as Māori ethnicity (18%), 104 of whom died, 92 (88%) due to cervical cancer, and 12 (12%) due to other causes; 59 (4%) identified as Pacific ethnicity, 20 of whom died, 20 (100%) due to cervical cancer; and, 80 (5%) identified as Asian ethnicity, 14 of whom died, 13 (93%) due to cervical cancer, and one (7%) due to other causes.[8]

Table 1 shows the characteristics of the 1,594 cervical cancer

Table 1: Characteristics of women diagnosed with cervical cancer in New Zealand, 1994 to 2005.

Characteristic	Ethnicity				All women
	Māori	Pacific	Asian	Other	
Women, n (%)	292 (18.3)	59 (3.7)	80 (5.0)	1163 (73.0)	1594
Travel time (median)					
Time to nearest GP	1.66	1.98	1.82	1.70	1.71
Time to nearest cancer centre	45.12	17.83	14.39	23.6	22.26
Travel distance (median)					
Distance to nearest GP	856.53	954.59	936.84	871.87	876.71
Distance to nearest cancer centre	50995.10	14382.42	12530.42	20742.58	20742.58
Travel time, categorised n (%)					
Time to nearest GP					
Low (>0.00 – <0.98)	83 (28.4)	19 (32.2)	19 (23.8)	283 (24.3)	404 (25.4)
Medium (≥0.98 – <2.96)	131 (44.9)	29 (49.2)	50 (62.5)	580 (49.9)	790 (49.6)
High (≥2.96 – 11.07)	51 (17.5)	10 (17.0)	11 (13.8)	248 (21.3)	320 (20.1)
Highest (≥11.07)	27 (9.3)	1 (1.7)	0	52 (4.5)	80 (5.0)
Time to nearest cancer centre					
Low (>0.00 – <12.38)	45 (15.4)	13 (22.0)	33 (41.3)	306 (26.3)	397 (24.9)
Medium (≥12.38 – <94.29)	154 (52.7)	43 (72.9)	42 (52.5)	561 (48.2)	800 (50.2)
High (≥94.29 – <268.56)	79 (27.1)	3 (5.1)	5 (6.3)	232 (20.0)	319 (20.0)
Highest (≥268.56)	14 (4.8)	0	0	64 (5.5)	78 (4.9)
Travel distance, categorised n (%)					
Distance to nearest GP					
Low (>0.00 – <523.39)	78 (26.7)	18 (30.5)	18 (22.5)	284 (24.4)	398 (25.0)
Medium (≥523.39 – <1573.03)	132 (45.2)	30 (50.9)	52 (65.0)	583 (50.1)	797 (50.0)
High (≥1573.03 – <9988.50)	57 (19.5)	10 (17.0)	10 (12.5)	241 (20.7)	318 (20.0)
Highest (≥9988.50)	25 (8.6)	1 (1.7)	0	55 (4.7)	81 (5.1)
Distance to nearest cancer centre					
Low (>0.00 – <8290.68)	44 (15.1)	12 (20.3)	29 (36.3)	314 (27.0)	399 (25.0)
Medium (≥8290.68 – <114780.00)	154 (52.7)	44 (74.6)	46 (57.5)	553 (47.6)	797 (50.0)
High (≥114780.00 – <313865.20)	74 (25.3)	3 (5.1)	5 (6.3)	238 (20.5)	320 (20.1)
Highest (≥313865.20)	20 (6.9)	0	0	58 (5.0)	78 (4.9)

Distance is in metres. Time is in minutes and proportions of minutes.

cases included in the analyses. The percentage of women in the highest category of travel time to the nearest GP (more than 11.07 minutes) varied by ethnicity (p=0.001) and ranged from 9.3% of Māori women to 0% of Asian women. No Pacific or Asian women lived in the highest category of travel time to the nearest cancer centre (more than 268.56 minutes) compared with 4.8% of Māori women and 5.5% of 'Other' women. Similar patterns were found for travel distance.

Both travel time and distance had little or no association with having ever been screened (Table 2), and adjustment for travel time or distance made almost no difference to the ethnic differences in screening rates. For example, the highest category of travel time to the nearest GP had an odds ratio (OR) of 0.99 (95% CI 0.57-1.72) for having ever been screened, compared to never screened. Adjustment for travel time made little change to the OR for 'ever screened' for Māori (a change from 0.54 to 0.55) or Pacific women (a change from 0.28 to 0.30).

The analyses shown in Table 2 were repeated (not shown) using 'regular screening' (see [4] for definition) as the outcome (all of those who were not regularly screened were classified as 'not regularly screened'). The ethnic differences were generally less than those shown in Table 2, but the patterns of the (lack of) effect of adjusting for travel time/distance were the same. For example, the OR for regular screening in Māori (compared to 'Other') women was 0.75 (95% CI 0.50-1.11) when adjusted for age, registration year and NZDep, and this changed to 0.76 (0.51-1.13) when adjusted

Table 2: Screening history and stage at diagnosis by ethnicity, socioeconomic position, and travel time/distance.

Characteristic	Odds ratios (95% CI) for ever screened vs never screened			Odds ratios (95% CI) for late stage diagnosis (stage II-IV) vs early stage diagnosis (0-IB2)		
	Adjusted for ethnicity, age, registration year and NZDep	Adjusted for ethnicity, age, registration year, NZDep and travel time	Adjusted for ethnicity, age, registration year, NZDep and travel distance	Adjusted for ethnicity, age, registration year and NZDep	Adjusted for age, registration year, NZDep and travel time	Adjusted for age, registration year, NZDep and travel distance
Ethnicity						
Māori	0.54 (0.40-0.73)	0.55 (0.40-0.75)	0.55 (0.40-0.75)	2.71 (1.98-3.72)	2.59 (1.88-3.56)	2.64 (1.92-3.63)
Pacific	0.28 (0.15-0.54)	0.30 (0.16-0.58)	0.30 (0.16-0.58)	1.39 (0.76-2.54)	1.26 (0.68-2.33)	1.26 (0.68-2.33)
Asian	0.42 (0.24-0.72)	0.42 (0.24-0.73)	0.43 (0.25-0.74)	1.07 (0.63-1.82)	1.04 (0.61-1.78)	1.04 (0.61-1.77)
Other	1.00	1.00	1.00	1.00	1.00	1.00
NZDep, quintiles						
1 (least deprived)	1.00	1.00	1.00	1.00	1.00	1.00
2	1.04 (0.68-1.59)	1.02 (0.66-1.57)	1.02 (0.66-1.56)	0.90 (0.57-1.43)	0.95 (0.59-1.51)	0.95 (0.59-1.51)
3	1.04 (0.70-1.56)	0.96 (0.64-1.45)	0.99 (0.66-1.49)	1.24 (0.81-1.90)	1.29 (0.84-2.00)	1.31 (0.84-2.02)
4	0.85 (0.58-1.25)	0.79 (0.53-1.18)	0.81 (0.54-1.20)	1.26 (0.84-1.89)	1.34 (0.88-2.05)	1.35 (0.89-2.07)
5 (most deprived)	1.20 (0.82-1.77)	1.10 (0.73-1.65)	1.12 (0.75-1.68)	1.09 (0.72-1.65)	1.21 (0.78-1.86)	1.20 (0.78-1.85)
Travel time/distance						
Time to nearest GP						
Low	1.00	1.00	–	1.00	1.00	–
Medium	1.22 (0.92-1.62)	1.26 (0.95-1.68)	–	1.28 (0.96-1.72)	1.27 (0.94-1.71)	–
High	1.00 (0.71-1.42)	1.02 (0.71-1.45)	–	1.17 (0.81-1.70)	1.12 (0.77-1.64)	–
Highest	0.99 (0.57-1.72)	0.91 (0.52-1.60)	–	1.67 (0.95-2.94)	1.70 (0.95-3.04)	–
Time to nearest cancer centre						
Low	1.00	1.00	–	1.00	1.00	–
Medium	0.88 (0.66-1.16)	0.90 (0.68-1.21)	–	1.33 (0.99-1.79)	1.32 (0.97-1.79)	–
High	1.21 (0.86-1.70)	1.31 (0.91-1.87)	–	1.09 (0.75-1.57)	1.06 (0.72-1.56)	–
Highest	1.04 (0.60-1.81)	1.09 (0.62-1.91)	–	0.58 (0.30-1.13)	0.56 (0.29-1.10)	–
Distance to nearest GP						
Low	1.00	–	1.00	1.00	–	1.00
Medium	1.08 (0.82-1.43)	–	1.11 (0.84-1.48)	1.12 (0.83-1.49)	–	1.10 (0.82-1.48)
High	1.01 (0.71-1.43)	–	1.01 (0.71-1.44)	1.18 (0.82-1.70)	–	1.14 (0.79-1.67)
Highest	0.92 (0.53-1.58)	–	0.83 (0.47-1.45)	1.37 (0.78-2.40)	–	1.48 (0.83-2.64)
Distance to nearest cancer centre						
Low	1.00	–	1.00	1.00	–	1.00
Medium	0.88 (0.66-1.17)	–	0.90 (0.67-1.21)	1.29 (0.96-1.74)	–	1.26 (0.93-1.71)
High	1.32 (0.93-1.86)	–	1.39 (0.97-1.99)	0.99 (0.69-1.43)	–	0.94 (0.64-1.38)
Highest	0.91 (0.52-1.59)	–	0.96 (0.54-1.69)	0.77 (0.41-1.46)	–	0.72 (0.38-1.38)

for travel time to the nearest GP and cancer centre, and to 0.76 (0.51-1.13) when adjusted for travel distance to the nearest GP and cancer centre. There was a similar lack of change in the findings for Pacific and Asian women when adjusting for travel time and distance (not shown).

Travel time to the nearest GP was non-significantly associated with late stage diagnosis (OR = 1.67, 95% CI 0.95-2.94) (Table 2), whereas travel time to the nearest cancer centre had a non-significant negative association with late stage diagnosis (OR=0.58, 95% CI 0.30-1.13). Adjustment for travel time reduced the excess risk of late-stage diagnosis by about 7% in Māori (the OR reduced from 2.71 to 2.59) and 33% in Pacific women (the OR reduced from 1.39 to 1.26). Similar findings were observed when adjusting for travel distance.

Travel time to the nearest GP and cancer centre were only weakly and inconsistently associated with cervical cancer-specific mortality (adjusted for stage) (Table 3); for example, the highest category of travel time to the nearest GP had a non-significant positive HR of 1.32 (95% CI 0.79-2.19) for mortality, whereas there was little or no association with travel time to the nearest cancer centre. Adjustment for travel time reduced the excess risk of mortality by 3% in Māori (the HR reduced from 1.59 to 1.57) and 13% in Pacific women (the HR reduced from 1.92 to 1.80). Similar findings were observed when using travel distance rather than travel time.

Discussion

This study found that travel time/distance is only weakly associated with cervical cancer screening, stage at diagnosis and mortality in NZ. Adjustment for travel time reduced the excess risk of late-stage diagnosis by about 7% in Māori and 33% in Pacific women, and adjustment for travel time reduced the excess risk of mortality by about 3% in Māori and 13% in Pacific women. Thus, the relatively weak effects of travel time primarily affect the ethnic

Table 3: Hazard ratios for mortality by ethnicity and travel time/distance.

Characteristic	Number of deaths	HR (95% CI) adjusted for age, registration year, ethnicity, stage and NZDep	HR (95% CI) adjusted for age, registration year, ethnicity, stage, NZDep and travel time	HR (95% CI) adjusted for age, registration year, ethnicity, stage, NZDep and travel distance
Ethnicity				
Māori	92	1.59 (1.21-2.08)	1.57 (1.19-2.06)	1.58 (1.20-2.07)
Pacific	20	1.92 (1.20-3.08)	1.80 (1.11-2.91)	1.90 (1.17-3.07)
Asian	13	0.70 (0.40-1.22)	0.67 (0.38-1.18)	0.68 (0.39-1.21)
Other	241	1.00	1.00	1.00
NZDep2001, quintiles				
1 (least deprived)	38	1.00	1.00	1.00
2	41	0.97 (0.62-1.51)	1.04 (0.66-1.63)	1.03 (0.65-1.62)
3	75	1.32 (0.89-1.96)	1.41 (0.94-2.11)	1.42 (0.95-2.14)
4	95	1.14 (0.78-1.66)	1.25 (0.84-1.86)	1.24 (0.83-1.85)
5 (most deprived)	117	1.15 (0.78-1.70)	1.29 (0.86-1.94)	1.25 (0.83-1.88)
Travel time/distance				
Time to nearest GP				
Low	85	1.00	1.00	–
Medium	193	1.13 (0.87-1.47)	1.13 (0.87-1.47)	–
High	67	1.33 (0.95-1.86)	1.33 (0.94-1.87)	–
Highest	21	1.28 (0.78-2.10)	1.32 (0.79-2.19)	–
Time to nearest cancer centre				
Low	81	1.00	1.00	–
Medium	201	1.12 (0.87-1.46)	1.08 (0.83-1.42)	–
High	71	1.03 (0.74-1.42)	0.96 (0.68-1.36)	–
Highest	13	1.02 (0.56-1.86)	0.96 (0.52-1.75)	–
Distance to nearest GP				
Low	90	1.00	–	1.00
Medium	187	0.98 (0.76-1.27)	–	0.98 (0.75-1.26)
High	72	1.23 (0.89-1.70)	–	1.23 (0.88-1.71)
Highest	17	0.93 (0.55-1.58)	–	0.95 (0.55-1.64)
Distance to nearest cancer centre				
Low	81	1.00	–	1.00
Medium	200	1.07 (0.82-1.40)	–	1.03 (0.79-1.35)
High	70	1.00 (0.72-1.38)	–	0.95 (0.67-1.34)
Highest	15	1.04 (0.59-1.84)	–	1.02 (0.57-1.81)

differences in stage at diagnosis, rather than subsequent survival (at a given stage of diagnosis).

A strength of the study is that the Cancer Registry Act (effective from 1994) makes cancer registration mandatory,[1] and case under-ascertainment unlikely.[25] Death registration is also mandatory in NZ, and can be linked to cancer registrations using the NHI number; thus there is a high probability that the study identified all of the cases that died in NZ. There may have been some misclassification of cause of death, but it is unlikely to have produced significant bias in the ethnic comparisons.[35] Furthermore, classification of the cause of death for patients on the NZCR is highly accurate since in cases that are registered prior to death, information from the NZCR is used to classify the underlying cause of death.[36]

This is the first study in NZ to measure the associations between travel time or distance (measured from the population weighted centroid of the CAU of residence of cervical cancer patients to the nearest GP and cancer centre), and cervical cancer-specific mortality. The few previous NZ studies that have examined the association between distance and cervical cancer mortality have used less precise measures of distance, such as aggregate measures based on population size.[6,8] Internationally, previous studies have also used less accurate methods of estimating distance/remoteness by using geometric centroids of census areas of residence (rather than population weighted centroids) and/or by estimating the travel time or distance to the centroids of census areas or to towns containing healthcare facilities (rather than to the specific location of a GP or cancer centre).[12,13,37] This is also the first study in NZ to use more direct measures of travel time or distance to assess their associations with cervical screening history.

The limitations of the study include the potential misclassification of ethnicity, which has been estimated to produce a 17-23% undercount of Māori cancer registrations[38,39] (this involves misclassification of ethnicity on registrations, rather than case under-ascertainment). The estimated undercount varies by time period (from about 23% in the 1990s to 15% in 2001-04).[39] Pacific and Asian cancer registrations are also estimated to be undercounted by 18-10%, and 38-13%, respectively, from the 1990s to mid-2000s.[39] Thus, the 'Other' ethnic group may contain some Māori, Pacific and Asian cases that were incorrectly classified, thereby diluting the ethnic survival differences. However, any resulting bias is likely to be small; for example, if mortality is double in Māori compared to 'Other' women, and 20% of Māori are misclassified as 'Other', this would only produce a bias in the HR of about 5% (i.e. if the true HR was 2.0, the observed HR would be 1.9). There is also evidence of a 6–7% under-count of Māori deaths,[38,40] but this would not bias the current study since the ethnicity recorded on the NZCR was used in all analyses. The classification of ethnicity was based on the wording of the corresponding census questions, and these have changed over time, but this is unlikely to have produced serious bias because the ethnicity recorded on the NZCR was also used to classify the corresponding deaths, and the analyses were adjusted for registration year. There may also be misclassification of area-based SEP, but any such misclassification is unlikely to be associated with subsequent survival and, if anything, is likely to produce under-estimates of the differences in survival between the various demographic groups. Only 74% of cases recorded on the NZCR between January 1994 and June 2005 had a FIGO code,[6] which could introduce selection bias, but a previous analysis found that there was little difference in overall cancer survival between those with and those without stage data.[41] It is also possible that there was residual confounding from inaccuracies in stage classification, as there were not sufficient numbers to adjust for more detailed stage at diagnosis. Thus, residual confounding by stage could explain some of the results. However, the fact that in our previous analysis[6] the Māori/'Other' differences in mortality almost completely disappeared when the analyses were adjusted for stage indicates that this is not likely to be a serious source of bias.

The estimates of travel time and distance are limited in their accuracy since we used domicile codes and were not able to estimate the time or distance from the patient's residential address, and we were not able to estimate the time or distance to the actual GP surgery or cancer centre that the patient attended. Women may choose to travel to a more distant GP, but it is unlikely that they would choose to travel to a more distant cancer centre since there are only six in NZ. The women that choose to travel to a more distant GP are presumably more likely to live nearby to several GPs, such that the actual time or distance travelled is not greatly different to our estimations. Thus, there may be some misclassification of travel time and distance but it is likely to be small. Travel time and distance to healthcare facilities may be associated with a number of social and cultural factors, but it is likely that these are generally related to both ethnicity and SEP, which we adjusted for in our analyses.

The findings from previous studies of travel time and/or distance and cancer survival in NZ have been inconsistent. Gill and Martin[21] found that after adjusting for other variables, distance from a cancer centre was not associated with poorer survival from upper gastrointestinal cancers. However, the relationship was complex as they found in univariate analyses that those living 51-100 km from a cancer centre had a poorer prognosis, but this difference disappeared when adjusted for gender, age, ethnicity, and NZDep96, although these analyses were not adjusted for stage/extent of disease.[21] Haynes et al.[22] found that after adjusting for extent of disease, increasing travel time to the nearest GP was associated with poorer survival for men with prostate cancer. Travel to the nearest cancer centre was also independently associated with poorer survival for colorectal and breast cancer patients, and less consistently associated with an adverse outcome in prostate cancer patients.[22] Half their sample lived within an estimated 2.1 minutes' drive to the nearest GP and more than half the sample lived within an estimated one hour's drive to the nearest cancer centre.[22] In contrast, Bennett et al.[20] found that after adjustment for stage and other variables distance from a cancer centre did not affect survival of women with breast cancer. "Just under a third of the cohort [examined by Bennett et al.[20]] lived within 10 km of a cancer centre. Another third lived 11-50 km away, 15% lived 51-100 km, and the remaining 22.3% lived more than 100 km away from a cancer centre." We have previously

shown that urban/rural residence had only a small effect on ethnic disparities in cervical cancer survival after adjusting for other variables including stage.[6]

Studies in other countries (such as Australia and the US, both substantially geographically larger than NZ) have also yielded inconsistent findings. In Australia, Aboriginal women in rural and remote areas were found to have a higher risk of death from cervical cancer than Aboriginal women living in urban areas.[12] The opposite pattern was observed for non-Aboriginal women. This study did not adjust for stage at diagnosis or screening history.[12] Jong et al.[37] were able to adjust for stage at diagnosis and found a significant increase in the relative excess risk of death for women with cervical cancer living in a remote area of New South Wales. In New York state, Tan et al.[13] found that increasing driving time (from resident's county seat to the nearest cancer treatment centre's county seat) led to an increase in the cervical cancer-specific death rate even when adjusting for population density. However, they were not able to adjust for stage. The pattern varied over time: in 1979 rural counties had an excess of around 1.5 deaths per 100,000 women compared with more densely populated counties, but by 2001 the rural counties had lower rates than the urban counties by roughly one death per 100,000 women.[13] Coker et al.[42] also found significantly shorter cervical cancer-specific survival in women living in more rural areas of Texas, after adjustment for stage (and treatment, age, race, SEP, and cell type). When stratified by stage, the association was only significant for women with regional/distant disease (compared with localised and unknown).[42]

The (weak) associations that we found between travel time and the ethnic differences in stage at diagnosis persisted after adjustment for screening history; similarly the ethnic differences in mortality persisted after adjustment for stage at diagnosis. Thus, there may be ethnic variations in access to treatment or in treatment quality, which in turn may be related to travel time.[37] There is some evidence for variation in treatment quality[43-45] and disease management[46] in NZ. However, the only study to date on treatment related to cervical cancer found that there were no differences in receipt of total/radical hysterectomy or brachytherapy between Māori and non-Māori after adjusting for age and stage of disease (excluding those with unknown stage).[47] The study was not able to examine external beam radiotherapy or chemotherapy which are generally provided on an outpatient basis.[47] A follow-up study that used focus groups to explore health service provider views on the finding of this study[47] that "...there were substantial improvements in the disparities between Māori and non-Māori women in cervical cancer incidence, mortality and survival..."[9] (between 1996 and 2006) found that the participants thought that one reason for the decrease in the inequalities might be a "trend towards improved consistency of practice [in terms of treatment] across the country...".[9]

These initial analyses of inequalities in cervical cancer survival in NZ provide timely baseline data. NZ commenced a vaccination program with Gardasil (Merck, Auckland, NZ) in September 2008, which will provide vaccinated women with immunity to human papillomavirus (HPV) subtypes 16, 18, 6 and 11. However, subtypes 16 and 18 are estimated to only account for about 70% of current cervical cancer cases (the exact figure is unknown because a national HPV prevalence survey has not been done), and the vaccine will not yield major benefits for several decades.

In summary, we assessed the associations of travel time and distance with cervical cancer screening, stage at diagnosis and mortality. We found that both travel time and distance are only weakly associated with these outcomes, but they may account for a small proportion of the ethnic differences in stage at diagnosis and mortality, particularly for Pacific women. These relatively weak effects of travel time primarily affect stage at diagnosis, rather than subsequent survival (at a given stage of diagnosis). It is possible that other factors, including differences in treatment and follow-up also play a role.

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