UNIVERSITY OF OSLO

HEALTH ECONOMICS RESEARCH PROGRAMME

The Importance of Municipality Characteristics for Cancer Survival in Norway:

A Multilevel Analysis

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Working Paper 2004: 8

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HERO 2004

Keywords: Cancer, Hospital, Multilevel, Region, Socio-economic, Survival, Education, Income, Religion, Unemployment

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Acknowledgements
The financial support from the Norwegian Cancer Society and the Health Economic Research Program at the University of Oslo (HERO) is greatly appreciated. Toril Berge has assisted in establishing the hospital data. The paper has also benefited from the helpful comments from colleagues at the Cancer Registry. Some of the data have been extracted from the Municipality Data Base operated by the Norwegian Social Science Data Services. That institution is not responsible for the analysis or interpretations.

Health Economics Research programme at the University of Oslo
Financial support from The Research Council of Norway is acknowledged.
ISSN 1501-9071, ISBN 82-7756-139-3

Abstract

Discrete-time hazard models for cancer mortality in cancer patients were estimated from register and census data to find out whether various socio-economic, ideational and institutional community factors had an impact on cancer survival in Norway in the 1990s, also beyond that of the corresponding individual-level variables. Such a multilevel approach has not been employed in previous analyses of cancer survival. In addition to confirming the better prognosis for patients with high education, it was found that, among patients at the same educational level, mortality was lowest for those who lived in a municipality where the average education was relatively high. The impact of economic resources was less pronounced. While a low unemployment rate in the municipality and high individual income reduced mortality among cancer patients, a high average income had no effect. Also those who lived in municipalities where a large proportion voted with the Christian Democratic Party had an advantage, which suggests a beneficial impact of affiliation with religious communities or support for the central Christian ideas. Moreover, there was an excess mortality among patients who lived in municipalities served by a relatively small hospital that did not have any responsibility beyond the county level. These patients may have got somewhat inadequate treatment at a low level in the hospital structure, or they have perhaps not wanted, or been able to fully comply with, the recommended follow-up treatment at the highest level. Even with such factors included in the model, there was significant regional variation. Cancer survival was relatively poor, net of differences in the stage distribution, in the capital, the central parts of Southern and Western Norway, and the peripheral parts of Southern Norway.

Introduction

Regional differences in the survival from some common malignancies have been documented for a few countries (e.g., Madsen, Norskov, Frolund & Hanash, 2002; Gatta, Buiatti, Conti, de Lisi, Falcini, Federico et al.,1997; Farrow, Samet & Hunt, 1996; Karjalainen, 1990), including Norway, which is in focus of the present study (Osnes & Aalen, 1999; Dickman, Gerbert & Hakulinen, 1997). Generally, when there is a significant geographic variation, it may be valuable to go beyond a pure description and try to identify the factors that produce it. Such knowledge may serve as important underpinning for health policies, and perhaps even contribute to the general understanding of the mechanisms involved in the progression of the malignant diseases. The list of possible explanations for geographic variations in cancer survival is long and includes differences in population composition, for example with respect to people's economic resources, the degree of social cohesion in the community, the availability of health care, and even climatic and other physical characteristics. These (and other) factors may affect cancer survival through three main channels: the characteristics of the tumour at the time of diagnosis, the treatment and care, and the co-morbidities and other so-called 'host factors' (e.g., Auvinen & Karjalainen, 1997; Wrigley, Roderick, George, Smith, Mullee & Goddard, 2003).

The objective of this study is to estimate the effects of some potentially important community variables on cancer mortality among adult men and women diagnosed with one of the 14 most common cancers in the 1990s, and see whether a regional variation remains when they are taken into account.

Three indicators of socio-economic resources are considered: education, income, and unemployment. If the only intention were to explain a regional variation appearing in simpler models, it would be sufficient to include these indicators at the aggregate level, and leave the corresponding individual-level variables out. However, there has been considerable discussion in the literature about socio-economic 'neighbourhood' effects, net of the corresponding individual-level effects, on all-cause mortality, drug abuse, juvenile delinquency and various other health and behaviour indicators (e.g. Wen, Browning & Cagney, 2003; Sampson, Morenoff and Gannon-Rowley, 2002; Kravdal 2002a), and it would indeed be interesting to see whether there are also such effects on cancer survival. More specifically, the patient's own education and income are included in the models along with the average education and income in the municipality, to see whether there are independent effects of the latter variables. In that case, socio-economic resources may, on the whole, be even more important than suggested by purely individual-level models. Unfortunately, unemployment is only available at the municipality level.

Moreover, an indicator of religious values in the municipalities is included. Religion has received very little attention in previous investigations of cancer survival, although there are many possible reasons for an effect. Another community variable that is considered in this analysis is the hospital structure, measured as proximity to hospitals of different size. Its importance has not been assessed in Norway before, and because of the discussions about possible gains from centralized hospital treatment in many countries, the findings should also have more general relevance. In a final step, stage at the time of diagnosis is entered into the model as a potentially important mediator.

Data and methods

Data

The data include life histories through 1999 for all men and women with a Norwegian identification number (i.e. all those who have lived in Norway for some time after 1960), and is an updated version of the data used in previous studies (e.g., Kravdal, 1995, 2000, 2001). The socio-demographic components of the biographies have been extracted from the Population Censuses of 1960, 1970, 1980 and 1990 and the Norwegian Population Register, and include information about date of death and whether the registered primary cause of death was cancer, all migration across municipality borders 1964-1999, annual income in 1970, 1980 and 1990, and the highest educational level attained as of 1960, 1970, 1980 and 1990. These register and census data have been linked with data from the Norwegian Cancer Registry, which from 1953 has recorded information on all cancer cases in the population. Data on the hospital structure are taken from Sintef (2000). Other characteristics of the municipalities are taken from the Municipality Data Base operated by the Norwegian Social Science Data Services (NSD), or they are produced by aggregation of the individual data.

The study is restricted to the 98992 women and men who were 20-90 years old when they were diagnosed with a first cancer of one of the fol1owing 14 types between 1990 and 1999: stomach cancer, colon cancer, rectum cancer, pancreas cancer, lung cancer, breast cancer, cervical cancer, ovarian cancer, prostate cancer, malignant melanoma, brain cancer, non-Hodgkin's lymphoma, or leukaemia. These were the most common cancers to die from in this age group. Inclusion of patients diagnosed with other types of cancer would have increased the material by one-fourth and given very similar estimates, according to additional model runs. Cancers diagnosed at autopsy are excluded.

Statistical approach

A discrete-time hazard regression model for cancer mortality in the selected group of cancer patients is estimated. This is the so-called corrected-survival approach. The appropriateness of the technique is discussed below. Each person contributes a series of 6-month observation intervals from the time of diagnosis. It is censored when the person dies from another cause, emigrates, or when the end of 1999 is reached (i.e. no more than 10 years of follow-up). Observation intervals of 6 months seem to be sufficiently short, because a length of 3 months gives the same results. The estimates are also essentially the same if it is instead censored no later than 2 or 5 years after diagnosis.

The disease characteristics and the patient's sex, education and income are fixed covariates. Education and income are taken from the most recent census before diagnosis, and are thus characteristics of the year 1980 or, in most cases, 1990. Age, period, duration since diagnosis, and municipality of residence are time-varying and refer to the situation at the start of the 6-month observation interval. The community variables describe the situation in the year that includes the start of the observation interval, or before, in the municipality in which the patient lived at that time (see elaboration below). Sex, age, period, cancer site and duration since diagnosis are included in all models. Preliminary analysis showed that further distinction into sub-sites would be unimportant.

Many covariates are categorical. The categories are defined after extensive experimentation, to make sure that no important patterns are concealed. Duration since diagnosis is grouped into intervals of 2-4 years, whereas 5-year groups are used for age. A good control for period turned out to be necessary for the estimation of community effects, so one-year groups are used.

Community variables

Place of residence is classified into 16 categories. Within each of the five so-called 'health regions', it is distinguished between the most peripheral areas (defined as municipalities that, according to Statistics Norway's classification of 1990, are not near any town or city; codes 0a and 0b), the central areas (that include or are near a quite large city, in addition to being within a 3-hour travel of one of the 6 largest cities; codes 2a and 3a), and other areas, denoted as semi-central. In addition, the capital, Oslo, which is more than twice as large as any other city (current population 0.5 million), is defined as a separate category. The five health regions are Eastern Norway (counties Oslo, Hedmark, Oppland,), Southern Norway (counties Akershus, Østfold, Buskerud, Vestfold, and Telemark, Aust- and Vest-Agder), Western Norway (counties Rogaland, Hordaland, and Sogn og Fjordane), Middle Norway (counties Møre og Romsdal, Sør-Trøndelag and Nord-Trøndelag), and Northern Norway (counties Nordland, Troms and Finnmark). The hospital system was reorganized in the last year of the study period (1999), with two counties in Southern Norway being transferred to Eastern Norway, but this change is not implemented in the analysis.

Average education in the municipality (in years; mean=11.3, s.d.=0.41) is calculated for each year by aggregating from the individual data on education at the time of the most recent previous census, pooling data for both sexes and all ages 20-90 together. Age standardization was found to be unimportant.

The unemployment rate in the municipality (in %; mean=3.5, s.d.=1.5) is defined for each year as the number of registered unemployed men (from NSD data), as an annual average, divided by the total male population of age 16-66 (from NSD data), in lack of information about the number of men in the labour force, which is a more commonly used denominator. A corresponding ratio for women is not calculated, because of a larger, and regionally varying, difference between the size of the labour force and the size of the total population for them.

Average income in the municipality (in 10000 NoK per years; mean=10.6, s.d.=2.3) is calculated for each year as the total annual income among the residents in the municipality (from NSD data) divided by the total population (from NSD data). For four municipalities, the total income is unavailable for a period of 1-4 years (0.1% of the observations). In these cases, a missing value indicator is set to 1 (otherwise 0) and the average income to 0 (any number would do).

The proportion voting for the Christian Democratic Party in the municipality (in %; mean = 10.3, s.d.=6.4) is taken from the NSD database and refers to the most recent previous Parliamentary election. From a social liberal or social democratic platform, the party tries to promote Christian values quite generally and argues, for example, for a 'warmer' society, a strengthening of the family as an institution, and restricted access to alcohol and tobacco. It is supported by about 1/10 of the voters as a national average, but a much larger proportion in the 'Bible belt' in the South and West).

Norway has a public health care system that takes charge of the cancer treatment. (The country also has some private clinics that offer treatment for other diseases that are not really life-threatening, and which are disregarded in this analysis). The hospital structure has three levels: Local hospitals have responsibility for one or more municipality, county hospitals are better equipped and have responsibility for all municipalities in a county, while regional hospitals are most advanced and have responsibility for all counties in a region. There are six such regional hospitals. The National Hospital and the Radium Hospital, both located in the capital, are regional hospitals for Southern Norway. Ullevål, also in the capital, is the regional hospital for Eastern Norway, whereas Bergen, Trondheim and Tromsø each have a regional hospital for Western, Middle and Northern Norway, respectively. Besides, the National Hospital and the Radium Hospital have a national responsibility for some special types of cancer.

The regional hospitals, except the two that also have a national responsibility, also serve as county hospitals for the counties in which they are located, and as local hospitals for some of the nearest municipalities. Similarly, county hospitals function as local hospitals for some neighbouring municipalities. The largest cities also have a few local hospitals without a wider responsibility, but the patients are free to use any of the higher-level hospitals in the city.

In this study, each municipality is assigned a local hospital, a county hospital (which can be the same as the local hospital), and a regional hospital (which can be the same as the county, and also the local, hospital). This hospital structure, taken from Sintef (2000), is combined with a matrix of distances, in hours of land travel, between the administrative centers of the municipalities (produced by InfoMap Norway AS; see Kopperud (2002)) to create an *access-to-hospital* variable. Its definition should be obvious from the description below and the table.

Results

Effects of place of residence relative to the central parts of Eastern Norway outside Oslo, according to five different models, are shown in Table 1. When sex, age, period, duration since diagnosis and cancer site are included as control variables, a relatively low mortality (significant at the 5% level) is seen only among cancer patients from the semi-central parts of Northern Norway (Model 1).

(Table 1 about here)

When the lower educational level and income of the patients in the peripheral areas are taken into account, the pattern changes slightly (Model 2). A relatively high mortality now shows up for the central parts of Southern Norway. The effects of these individual-level socio-economic variables accord well with those reported in previous Norwegian studies (Kravdal, 2000, 2003).

Inclusion of some community variables, most of which have significant effects, produces a disadvantage also for Oslo and the peripheral parts of Southern Norway, while a low mortality appears in the peripheral parts of Northern Norway (Model 3).

Patients who lived in municipalities where the average education was high, or where a high proportion voted with the Christian Democratic Party, had relatively low mortality. An increase of two standard deviations in these two variables is associated with a mortality reduction of 9% and 4%, respectively. The impact of economic resources in the community is less clear. Whereas a low unemployment rate reduced mortality among cancer patients (by 4% as a response to a change of two standard deviations), a high average income had no effect. In fact, there are even indications of an adverse effect of average income.

Mortality was relatively high for patients who lived in a municipality served by a local hospital that was not also a county hospital and located more than two hours away from the regional hospital (Model 4). An even longer travel time did not add to the disadvantage (not shown). When the hospital structure is included in the models, the difference between Oslo and the semi-central and peripheral parts of Northern Norway becomes larger.

Inclusion of stage at the time of diagnosis has some impact on the geographic effects (Model 5). For example, the low mortality among cancer patients in some parts of Northern Norway that appears in simpler models seems to be a result of a favourable stage distribution. Moreover, cancers tend to be detected early in Oslo as well, so the capital comes out even worse when this variable is taken into account. In addition, a significantly elevated mortality is estimated for the central parts of Western Norway.

Effects of the socio-economic or institutional variables are also somewhat changed by the inclusion of stage: The effect of the religiosity indicator is no longer quite significant, and a disadvantage appears for a larger group of municipalities that are served by a relatively small local hospital.

Discussion

A multilevel perspective on the importance of education

Evidence from many different countries suggests that socio-economic resources are positively associated with survival. The studies have been based on either ecological variables, such as the average income within a census tract, or various indicators of the patients' own socio-economic position (Kogevinas & Porta, 1997). However, we know nothing about the *net* impact of the socio-economic resources of the community, above and beyond that of the corresponding individual factors. While many investigations of all-cause mortality or various health indicators have addressed the independent effects of poverty concentration, social cohesion or other community characteristics (Wen et al., 2003; Sampson et al., 2002), no previous analysis of cancer survival has considered both individual- and community-level socio-economic factors.

In this investigation, based on data from a supposedly very egalitarian country, it is found that a patient who lives in a municipality where the average educational level is high has a better prognosis than another patient who has the same education, but who lives in an area where people are generally less educated. Some of this influence of community education can be attributed to earlier detection of the tumour; the remaining is due to host factors or treatment. One possible explanation for such effects may be that other people's education influences *their* life style and health consciousness, which is transmitted to the individual under consideration by more or less direct mechanisms of social learning or imitation (for discussion of such social interaction processes, see e.g. Montgomery and Casterline, 1996). In principle, also the quality of the health care institutions may be involved. While the same formal qualifications are required for nurses and physicians throughout the country, some municipalities struggle with vacancies or find it difficult to attract experienced personnel, and such problems are perhaps to some extent a consequence of the level of community education.

However, the effect of community education may also be partly spurious. The general level of education is determined by the resources and attitudes in the population, as well as institutional and other so-called 'global' characteristics that are not only a sum of individual characteristics, and these factors may also have an impact on the individual cancer patient's mortality. Even though region of residence and other municipality variables are included, there is still room for such unobserved determinants of education. Besides, community education may be associated with various unobserved characteristics of the individual woman herself because of selective migration into or out of the municipality.

The estimated association between average education and mortality among cancer patients is quite strong. As an illustration, based on a simple idea that the effects are purely causal, a one-year general increase in the educational level in a municipality will reduce cancer mortality among cancer patients by 11% through the community effect and 5% through the individual effect (according to a model that includes a continuous variable for individual education). Such a large contribution to the social inequality in cancer survival obviously deserves further investigation.

Other socio-economic effects

The importance of income should not necessarily be expected to be similar to that of education. For example, a high purchasing power in the community, or for the individual, may well have negative implications for some aspects of the life style. Poverty and income have received more attention than education in multilevel health studies, and while many authors have reported significant effects, there are also studies where a net community effect of economic resources did not show up (Sloggett & Joshi, 1994). In one of the studies that have addressed the impact of both income and education, the latter was clearly the most important (Wen et al., 2003).

On the whole, the estimates shown here suggest a generally weaker effect of economic factors than of education. A high unemployment rate is associated with poor prognosis, but average income is found to be unimportant. One possible explanation for the difference between the effect of average income and that of unemployment is that the latter signals a *change* in economic resources (in spite of the relatively generous support systems), combined with a contraction of the social network and a certain stigma. The psychosocial stress resulting from all this may be substantial (Martkainen & Valkonen, 1996). Besides, without a corresponding individual-level variable in the model, the estimate for unemployment reflects a combination of individual and community effects. In addition, there may be other individual and community factors behind unemployment than behind a more stable low income.

The individual income variable has obvious limitations, because it refers to one particular year before cancer diagnosis, in which the person may have earned much less or much more than usual. Anyway, a significant negative effect is estimated, just as in another Norwegian study (Kravdal, 2000). The same pattern would have appeared if those with no income, most of whom are young or elderly, had been singled out as a separate category (not shown).

Religious attitudes

There is a weak negative association between mortality among cancer patients and the proportion voting with the Christian Democratic Party. This variable is likely to capture the religious attitudes among people in the community, as well as for the individual cancer patient (in the absence of a corresponding individual-level variable).

In one of the very few other cancer survival studies that have considered religious indicators, Zollinger, Phillips & Kuzma (1984) concluded that the beneficial impact of being a Seventh-day Adventist was a result of early detection of the tumour. The models estimated here suggest that the timing of the diagnosis may indeed be a relevant intermediate factor, but there are indications of host factor or treatment effects as well.

One possible reason for the importance of religion may be that it is linked with a relatively strong social support system and healthy life style (Hummer, Roger, Nam & Ellison, 1999; Waite & Lehrer, 2003). Both these factors may have a bearing on cancer survival. (The social support system also includes the nearest family. The patient's marital status was included in additional models, and found to be a strong determinant, as already reported in Kravdal (2001, 2003), but its inclusion had very little impact on the other effect estimates.) It has also been speculated whether religion is important for cancer patients' coping strategies, with possible implications for survival, but the evidence is weak (e.g. Feher & Maly 1999).

Access to hospital

Since about 1990, the demand for advanced cancer treatment and diagnosis in each health region has been met within that region, by the regional hospital. In the mid-1990s, only 5% of the cancer patients were referred to an extra-regional, usually national-level, hospital for treatment (Norges Offentlige Utredninger, 1997). Presumably, all cancer patients get some kind of primary treatment, and typically at the hospital routinely recommended for people in the municipality with that particular disease. Some primary treatment is provided at the regional level, but the less advanced primary treatment is usually given at the county, or even local, hospitals. Also follow-up or palliative treatment, to the extent that it is recommended or wanted by the patients, can be given at different levels. Thus, some patients may get all their treatment at a hospital with only a county or local responsibility; some may get the follow-up treatment at that level after having had the primary treatment at the regional hospital (perhaps based on advice from the regional hospital); some may get all their treatment at the highest level; and some may, for example, be sent to a regional hospital for radiation therapy after primary surgery at a lower-level hospital.

It is not unlikely that the primary cancer surgery may be better, with a potentially beneficial impact on survival, at larger hospitals that have higher case loads or for other reasons more expertise. This has been shown in studies both from Norway and other countries (Blomquist, Ekbom, Nyren, Krusemo, Bergstom & Adami, 1999; Jensena, Ewertz, Cold, Storm & Overgaard, 2003; Helsedirektoratet, 1993; Tingulstad, Skjeldestad & Hagen, 2003; Raabe, Kaaresen & Fossaa, 1997; Simons, Ker, Groshen, Gee, Anthone, Ortega et al., 1997). For example, more lymph nodes may be removed in a breast cancer operation (with consequences also for stage determination), or more modern techniques may be used when removing a rectal tumour. Also other kinds of treatment may be less adequate at the smaller hospitals.

The estimates reported in this study are consistent with the idea that treatment at a relatively small hospital may be somewhat poorer than that provided elsewhere. Unfortunately, the hospitals that have actually treated the patients are not identified in the data, but it is not unlikely that those who live in a municipality served by a hospital that only has a local or county responsibility have got some of their treatment at that hospital. If it is the primary treatment at the lower-level hospital that is somewhat inadequate, centralization of these services to the regional level would be advantageous. However, if the somewhat poorer survival instead reflects a lower quality of the follow-up treatment at a smaller hospital, the benefits from centralization are less obvious. The reason is that, if there were no possibilities for follow-up treatment at a local or county hospital, some patients might decide to forego such treatment altogether. Another interpretation of the results is that the primary treatment at the low level may be sufficiently good, but that some patients do not accept or manage to comply with the recommended follow-up treatment at the regional level.

The host factor explanation seems less plausible, although not entirely without logic. It would imply that cancer patients in the municipalities served by smaller hospitals suffer from more co-morbidities and a generally poorer health as a result of inadequate check-ups and treatment for other diseases.

One might expect that the smaller hospitals would take more of the responsibility for the cancer treatment if the regional hospital is far away, or that the patients in that case would be more hesitant to make use of the services they might be offered at the regional hospital. In accordance with the latter possibility, it was reported in the mid-1990s that the use of radiation therapy for breast and prostate cancer within Southern Norway varied with the distance from the regional hospital (Norges Offentlige Utredninger, 1997). However, no clear distance effects appear in the present study. Thus, it seems that the decisions about which treatment to offer at different levels of the hospital structure are based on other factors, or that the patients may consider other disadvantages, such as perhaps being in a large hospital they have never visited before, more crucial than the distance. (Also the distance to the local hospital, which one might expect to have some implications for the follow-up treatment that is recommended or accepted, in addition to influencing the timing of the diagnosis, turned out to be unimportant, according to additional models. Besides, the distance to the national hospitals in Oslo, relevant only for three regions, was unimportant.)

Whatever the explanation of the estimated hospital effects, it is important to keep in mind that they are fairly weak. The differences in survival are about 5-10%. In other words, the limited access to or use of large hospitals in some parts of the country does not seem to constitute a major problem with respect to cancer survival.

For some reason, cancers are diagnosed relatively early when the local hospital is not also a regional hospital, but within 2-hour reach of such a hospital. Thus, if it is not conditioned on stage, mortality is significantly elevated only if the local hospital is not also a county or regional hospital and if it is more than 2 hours away from a regional hospital. However, there are indications of an excess mortality also in other municipalities served by a relatively small local hospital.

The central/peripheral dimension is, of course, closely correlated with the hospital variable, but it seems possible to separate the effects. Although some changes in the hospital effects could be seen when other definitions of central and peripheral were tried (while other estimates were very little affected), the main conclusion is robust to such re-specification.

Remaining regional differences

There is no less variation between regions when the indicators of socio-economic resources, religious values and the hospital system are included in the model, than in the simpler models, but the ranking of the regions is different. According to the most complex model, except that stage is left out, survival is poorest in Oslo and the central parts of Southern Norway, while it is lowest in the less central parts of Northern Norway. The size of the gap is about 20%, just as between the better-educated patients and those with only compulsory education. For reasons not speculated about here, cancer patients in the less central parts of Northern Norway and in Oslo are diagnosed at an earlier stage than what is common in many other areas. Therefore, Oslo's disadvantage is even more pronounced when stage is included, while the advantage for Northern Norway disappears. In these models, there is also a high mortality among cancer patients in the central parts of Western Norway and peripheral parts of Southern Norway.

These regional variations in the most complex model must be due to treatment or the patients' health at the time of diagnosis. In consistence with the latter explanation, the age-standardized all-cause mortality rate for people without cancer (denoted below as non-cancer mortality), is higher in Oslo than in any other area when the socio-economic composition is taken into account (not shown). This may be a result of an urban life style. A similar explanation might seem plausible for the central parts of Southern Norway (and especially because cancer survival is particularly low in the sub-area close to Oslo, rather than in that surrounding the smaller city Kristiansand; not shown) and the central part of Western Norway (which includes the cities Stavanger and Bergen). However, none of these regions have particularly high non-cancer mortality (not shown).

The regional differences may, in principle, also be a result of differences in the quality of the treatment, given the access to hospitals as defined here. For example, perhaps the cancer patients in or near Oslo get less adequate help at hospitals, in health care centres, or in their homes, than people in other municipalities with a similar access to hospitals? Or perhaps this is a more appropriate explanation for the poor survival in the peripheral parts of Southern Norway, which cannot be an urbanization effect? Such quality differences have not been documented, but it must be legitimate to raise the question.

Alternatively, the net regional variation might reflect differences in various life style factors that are important for the patients' health at the time of diagnosis, and that are shaped by socio-economic, ideational, or physical factors not adequately captured by the included variables (in addition to being unrelated to urbanization, which is dealt with above).

Diagnostics and 'stage migration'

Particularly intensive diagnostic procedures, as a result of the patient's personal initiative or special thoroughness on the part of the hospital, may lead to the detection of quite harmless asymptomatic tumours that otherwise would not have been seen. For example, the prevalence of well-differentiated localized prostate cancer may be particularly high in some population groups that are subject to much PSA screening and make the prostate cancer prognosis for these groups appear very good. There is no easy way to correct for this, but it is at least reassuring that exclusion of all localized prostate tumours from the material left the estimates almost unchanged (not shown).

Another possible consequence of intensive diagnostic procedures is, for example, that a regional spread is recorded rather than the local stage that otherwise would have been assigned. This would contribute positively to the survival rates in both categories. However, because the control for recorded stage has a rather modest impact on the estimates, it is hard to believe that this kind of stage *mis*-classification is a crucial factor.

Modelling issues

The corrected-survival approach employed in this study may not always give a good impression of the aggressiveness of the disease. That is because it is often difficult for the physician who writes the death certificate to identify a primary cause: Also some of the deaths that are *not* registered as being primarily a result of cancer may actually be more rightly considered cancer deaths. An alternative that has been much used is the relative-survival approach, which is a comparison of all-cause mortality in cancer patients with that in the 'normal' population. The relative-survival approach is usually based on only age, sex and period variations in 'normal' mortality. In a few extended versions, however, other socio-demographic variations have been taken into account. In a recent study, such an extended version of the relative-survival approach was compared with the corrected-survival approach (and the slightly poorer observed-survival approach), with a focus on effects of education and marital status (Kravdal, 2002b). The effects differed very little, and there is no reason to expect larger differences for the community variables.

Another potential problem is that patients who live in the same municipality may have something in common that is not captured by the available variables. Failure to account for such unobserved community-level factors will generally bias the standard errors of the community-level effects downwards. In this study, it was therefore checked whether it was important to include an error term specific for each combination of municipality and year (assumed to be drawn independently from an approximately normal distribution with a variance to be estimated). Inclusion of a community-level error term is standard procedure in multilevel modelling (e.g. Goldstein, 1995). These additional models were estimated in aML (Lillard & Panis, 2000). It would seem more reasonable to use a three-level structure, with municipality as a level above year, but this could not be done because aML (and other software) runs into numerical problems when there is a large number of sub-observations per highest-level observation. Fortunately, in these models that included 'municipality-year' error terms, the standard deviations of the community-level effects were, on the whole, only about 5% larger than reported in the tables in this study.

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Table 1. Effects (with 95% CI) of individual and community characteristics on mortality among Norwegian cancer patients 1990-99, according to different models[a]

	Model 1	Model 2	Model 3	Model 4	Model 5	N
HEALTH REGION AND CENTRAL/PERIPHERAL						
Eastern, Oslo	1.01 (0.96-1.07)	1.06* (1.00-1.12)	1.08** (1.01-1.16)	1.13*** (1.04-1.24)	1.22*** (1.11-1.34)	4848
Central, excl Oslo[b]	1	1	1	1	1	2291
Semi-central	1.05 (0.96-1.15)	1.03 (0.94-1.13)	1.01 (0.92-1.11)	1.01 (0.92-1.11)	1.03 (0.94-1.14)	738
Peripheral	1.01 (0.93-1.11)	1.01 (0.92-1.10)	1.01 (0.93-1.11)	1.00 (0.92-1.10)	1.00 (0.91-1.10)	802
Southern, Central	1.03 (0.98-1.08)	1.05** (1.00-1.11)	1.09*** (1.03-1.14)	1.09*** (1.03-1.15)	1.09*** (1.03-1.16)	13219
Semi-central	0.96 (0.88-1.05)	0.96 (0.88-1.04)	1.00 (0.92-1.09)	0.97 (0.88-1.06)	1.04 (0.94-1.14)	915
Peripheral	1.10 (0.98-1.24)	1.10 (0.98-1.23)	1.14** (1.01-1.29)	1.12* (0.99-1.27)	1.16** (1.02-1.31)	405
Western, Central	0.95* (0.90-1.00)	0.97 (0.92-1.02)	1.01 (0.95-1.07)	1.04 (0.97-1.11)	1.08** (1.01-1.16)	5422
Semi-central	0.96 (0.88-1.05)	0.97 (0.88-1.06)	1.03 (0.93-1.13)	1.03 (0.93-1.13)	1.08 (0.98-1.20)	804
Peripheral	0.96 (0.89-1.03)	0.97 (0.90-1.04)	1.02 (0.94-1.10)	1.00 (0.93-1.08)	1.05 (0.96-1.14)	1410
Middle, Central	0.95 (0.89-1.01)	0.96 (0.90-1.03)	1.00 (0.93-1.07)	1.03 (0.95-1.12)	1.03 (0.95-1.12)	2057
Semi-central	0.95 (0.89-1.01)	0.95 (0.89-1.01)	0.99 (0.93-1.06)	1.00 (0.93-1.07)	1.02 (0.95-1.10)	2295
Peripheral	0.96 (0.89-1.03)	0.96 (0.89-1.03)	0.99 (0.92-1.07)	0.99 (0.90-1.07)	1.01 (0.93-1.10)	1350
Northern, Central	0.93 (0.83-1.04)	0.94 (0.84-1.05)	0.97 (0.86-1.09)	1.01 (0.89-1.15)	1.06 (0.93-1.21)	429
Semi-central	0.90*** (0.83-0.97)	0.90*** (0.83-0.97)	0.90*** (0.84-0.98)	0.89*** (0.82-0.97)	0.96 (0.88-1.04)	1257
Peripheral	0.96 (0.91-1.03)	0.95* (0.89-1.01)	0.93** (0.87-0.99)	0.90*** (0.84-0.97)	0.97 (0.90-1.04)	2402
EDUCATION						
9 years[b]		1	1	1	1	20438
10-12 years		0.90*** (0.87-0.92)	0.90*** (0.88-0.92)	0.90*** (0.88-0.92)	0.91*** (0.89-0.93)	15889
13-16 years		0.84*** (0.80-0.87)	0.85*** (0.81-0.88)	0.85*** (0.81-0.88)	0.87*** (0.83-0.91)	3407
17- years		0.80*** (0.75-0.86)	0.82*** (0.76-0.88)	0.82*** (0.76-0.88)	0.85*** (0.79-0.92)	994
INCOME (in 10000 NOK)		0.994*** (0.992-0.995)	0.994*** (0.992-0.995)	0.994*** (0.992-0.995)	0.992*** (0.990-0.993)	
AVERGE EDUCATION (years)			0.888*** (0.839-0.940)	0.892*** (0.842-0.946)	0.927** (0.873-0.985)	
UNEMPLOYMENT RATE (%)			1.014** (1.002-1.026)	1.017*** (1.005-1.030)	1.024*** (1.011-1.037)	
AVERAGE INCOME (in 10000 NOK)			1.013* (0.998-1.029)	1.012 (0.997-1.028)	1.007 (0.991-1.023)	
PROPORTION VOTING FOR WITH CHRISTIAN DEMOCRATIC PARTY (%)			0.997** (0.994-0.999)	0.996** (0.992-0.999)	0.997* (0.994-1.000)	

ACCESS TO HOSPITAL			
Local hospital is also regional hospital[b]	1	1	10418
Local hospital is *not* also regional hospital			
Regional hospital < 2 hours away from local hospital			
Local hospital is also county hospital	1.05* (0.99-1.11)	1.07** (1.01-1.13)	10196
Local hospital is *not* also county hospital	1.05 (0.99-1.12)	1.09*** (1.02-1.17)	4144
Regional hospital > 2 hours away from local hospital			
Local hospital is also county hospital	1.04* (0.99-1.09)	1.04* (0.99-1.10)	12033
Local hospital is *not* also county hospital	1.11*** (1.04-1.19)	1.11*** (1.04-1.18)	3937
STAGE			
Localized[b]		1	12380
Regional spread		2.04*** (1.97-2.11)	8318
Distant spread		9.74*** (9.43-10.06)	16782
Unknown		2.41*** (2.29-2.53)	3208

[a] The models also include sex, age, period, cancer site, duration since diagnosis, and (for models 3,4 and 5) an indicator that is set to 1 for municipalities for which average income is missing.
[b] Reference category

N= Number of deaths to cancer patients in this category

Significance levels p< 0.10 *; p < 0.05 **; p < 0.01 ***