

Introduction of positron emission tomography into the Western Norwegian Health Region: Regional balance in resource utilization from 2009 to 2014

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Summary

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Background The aim was to compare resource utilization across the four health trusts within the Western Norway Regional Health Authority since the establishment of positron emission tomography (PET) at Haukeland University Hospital in Bergen in 2009.

Methods Metadata from all PET examinations from 2009 to 2014 were automatically imported from the PET centre's central production database into a custom-developed database system, MDCake. A PET examination was defined as a procedure based on a single injection of radioactive tracer. The patients' place of residence and tentative diagnosis were coded based on the available clinical information.

Results The total number of PET examinations increased from 293 in 2009 to 1616 in 2014. The number of PET examinations per year increased across all diagnostic groups, but plateaued for lung cancer, gastrointestinal cancer and malignant melanoma since 2013. The number of examinations per capita was evenly distributed between the three northern health trusts with an average of 1260 PET studies per million inhabitants in 2014. However, patients residing in the most southerly health trust received between 44% (2010) and 27% (2014; $P < 0.001$, repeated measures ANOVA) fewer examinations per capita per year.

Conclusion Centralized PET in the Western Norwegian health region meets the current clinical demand for patients residing in the three northern health trusts while patients from the most southern health trust receive approximately 30% fewer PET examinations. Access to specialized health care should be monitored routinely in order to identify inequalities in referral patterns and resource utilization.

Introduction

Positron emission tomography (PET) was established as a useful method for (re-)staging solid malignant tumours already in the late 1990s (Reske & Kotzerke, 2001; Fletcher et al., 2008). Compared with other Scandinavian countries, PET was introduced to Norway relatively late (Norderhaug et al., 2011). The first two dedicated PET/computed tomography (CT) scanners were installed at Oslo University Hospital (OUH) in 2005 and 2006. The country's third scanner was established by the Western Norway Regional Health Authority (Helse Vest RHF; 'Western Health Region') and Bergen Health Trust (Helse Bergen HF) at Haukeland

University Hospital (HUH) in Bergen in 2009. Since late 2013 PET/CT scanners are available in all four Norwegian health regions (Fig. 1).

The PET-centre at HUH serves the entire Western Health Region with a population of 1.1 million coming from four different health trusts (Fig. 1). Since 2009, we have systematically monitored our production of PET examinations in respect to referring institutions and disease groups as part of our internal quality control. Our key questions were: Does the PET centre in Bergen meet the clinical demand in respect to the different diagnostic groups? And: Do patients in the Western Health Region have equal access to PET examinations?

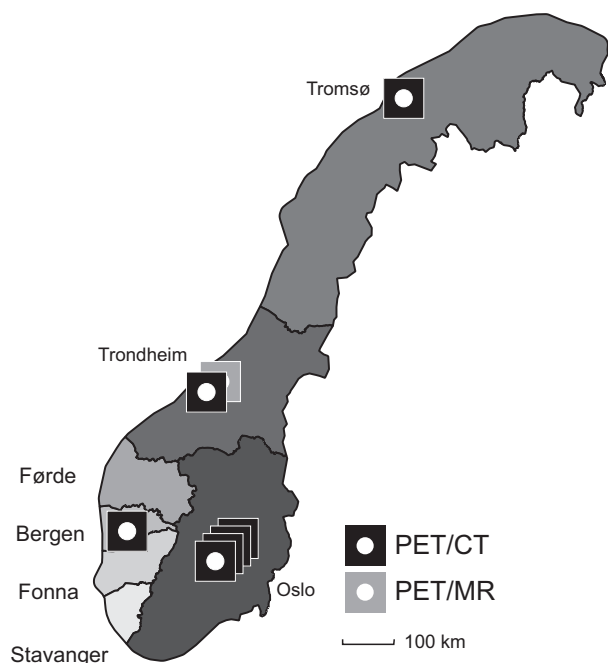


Figure 1 PET scanners and health regions in Norway. The Northern Region (Tromsø; 1 PET/CT) has a population of 454 000, the Central Region (Trondheim; 1 PET/CT and 1 PET/MR) 663 000, and the South Eastern Region (Oslo; 4 PET/CT) 2.81 millions. The Western Health Region (1 PET/CT; 1.07 millions) is divided into four Health Trusts: Førde (109 000 inhabitants), Bergen (434 000), Fonna (178 000) and Stavanger (352 000).

Methods

The first PET/CT in Bergen was performed on 29 April 2009. Initially, F-18-fluorodeoxyglucose (FDG) was delivered by plane from GE Healthcare in Oslo. Since Good Manufacturing Practice (GMP) certification in March 2011, FDG is routinely produced in the centre's own radiopharmaceutical production facility. In addition to FDG, anti-1-amino-3-[¹⁸F]fluorocyclobutyl-1-carboxylic acid (FACBC) produced by GE Healthcare has been available for prostate cancer imaging since late 2014. PET examinations in Norway are reimbursed by public health care. As a rule, referrals to PET examinations are limited to the specialist health service.

The study includes all FDG PET examinations conducted at Bergen PET-centre between 29 April 2009 and 31 December 2014. For the purpose of this study, a dedicated application was implemented under MDCake, our self-developed open source client-server database for biomedical research (Biermann, 2014; Biermann et al., 2015). As part of the general imaging and image reading workflow, all image data acquired at Bergen PET-centre are routinely transferred to the centre's central DICOM (Digital Imaging and Communications in Medicine) server (Segami Oasis 1.9.x; Segami Corporation, Columbia, MD, USA). A link was set up between the central DICOM server and MDCake by means of a special automatic import module implemented in PHP (<http://php.net>). On import

into MDCake, data were automatically anonymized and given unique check sums to eliminate data duplication. All imported datasets were verified against the department's Radiology Information System (RIS) (Agfa HealthCare NV, Mortsel, Belgium). For each patient examination the following items were manually entered into the MDCake database: the postcode of the patient's place of residence at the time of the PET examination and the tentative clinical diagnosis coded according to the International Classification of Diseases version 10 (ICD-10) based on the available clinical information. In case of a PET examination encompassing several DICOM studies (e.g. contrast-enhanced PET/CT head/neck in addition to a PET/CT of the torso), the studies with the lowest resolution CTs were marked as 'hidden' in MDCake to eliminate duplicate counting in the analysis.

In the context of this analysis, a PET examination is a complete imaging procedure based on a single injection of radioactive drug in one patient regardless of the number of acquired DICOM studies or series. Population figures are from 1 April 2014 (Statistics Norway, <https://www.ssb.no/>). Data analysis was performed using the statistical program R (Biermann, 2014; R Core Team, 2015). To detect differences between different patient groups over time, the time series were normalized on the production year 2014, and analysis of variance (repeated measures ANOVA) was performed complemented by Tukey's method with a significance level of 5% (two-sided). The project was conducted as a quality surveillance study in full accordance with the guidelines issued by the institutional review board (IRB) and current Norwegian legislation.

To supplement the data from our own institution, we conducted a national survey in February 2015, asking all institutions providing PET in Norway for the number of PET examinations (defined as tracer injections) per tracer per year.

Results

Since the introduction of PET at OUH in 2005, the number of PET examinations performed in Norway increased from 80 in 2005 to 7525 in 2014 (Fig. 2). At Bergen PET-centre, the number of examinations rose from 293 in 2009 to 1616 in 2014 (Fig. 2). All four health trusts contributed to the increase (Fig. 3). Patients residing in the Bergen, Fonna, and Førde Health Trusts underwent between 463 (2010) and 1260 (2014) PET examinations per million inhabitants per year (Fig. 4). The frequency of PET examinations for patients residing in Stavanger Health Trust was consistently between 27 to 44% lower ($P < 0.001$) compared to the other three (Fig. 4). Ninety percent of all PET examinations concerned malignant disease. Patients with gastrointestinal cancer (mainly colorectal cancer) and lung cancer comprised the two largest diagnostic groups (Fig. 5). The number of PET examinations in both these groups as well as for patients with malignant melanoma has remained stable since 2013, while demand in the other diagnostic groups is still increasing. A total of 163

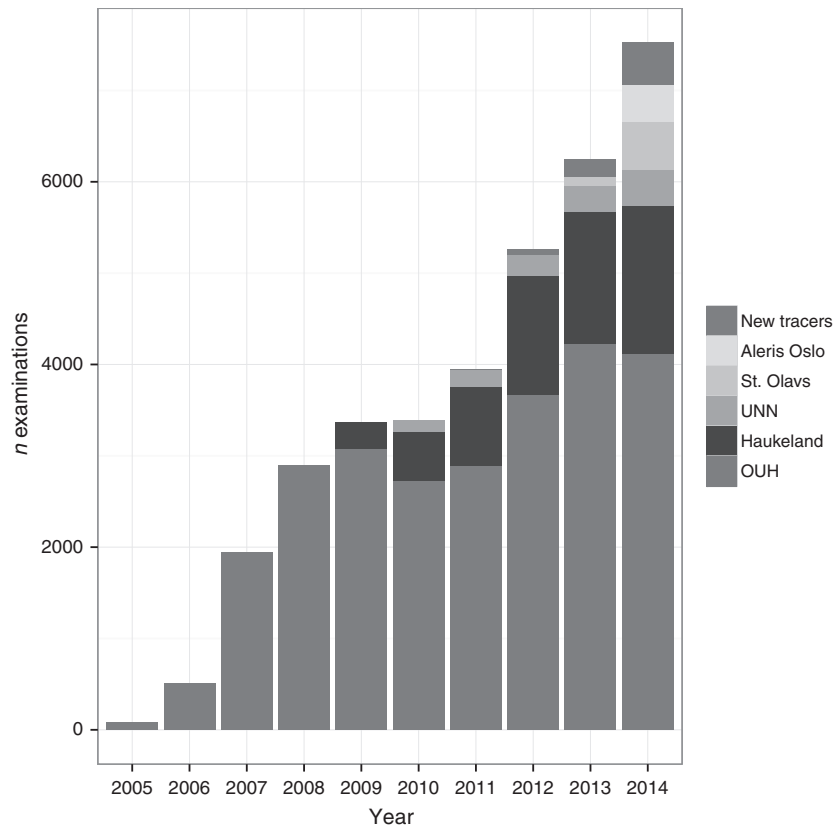


Figure 2 Number of PET examinations in Norway from 2005 to 2014. The main columns indicate the number of F-18-FDG-PET-examinations at the different institutions (for Aleris, a private institute in Oslo, only patients with public reimbursement). The category 'New tracers' includes sodium fluoride (2012: OUH 32, 2014: OUH 29, Aleris 2), F18-FACBC (2012: OUH 24, 2013: OUH 193, 2014: OUH 225, Aleris 159, HUH 25), and F-18-FDOPA (2013: OUH 3, 2014: OUH 22).

PET examinations were conducted for planning of external beam radiation therapy, 67 of these in 2014.

Discussion

The number of PET examinations per capita per year varies widely between different countries and regions: In Japan, 295 institutes performed 505 990 PET-CT examinations in 2012, amounting to 5500 PET examinations per million inhabitants per year (Kinuya et al., 2014). In Europe, 551 PET/CT cameras produced about 900 000 examinations in the same year, averaging approximately 1200 examinations per million per year in 2012 (European Association of Nuclear Medicine, Status of Nuclear Medicine 2012, e-mail 13 July 2015). In Denmark, Norway's southern neighbour, 27 776 PET examinations were acquired in 2011, amounting to approximately 4900 per million per year (Danish Institute of Radiation Protection, 2012). Our own national survey documented 7525 PET examinations in Norway in 2014, 1500 per million per year. Thus, use of PET in Norway has at last reached European standard (Norderhaug et al., 2011) while Denmark is closer to Japanese practice.

Publications on production data from single institutions are scarce. Odense Hospital, which serves a region with a population of 1.2 million in central Denmark, published data on the upstart of their own PET-centre. However, they focused their analyses on diagnostic groups and outcomes and did not examine the distribution of PET studies inside their geo-

graphic area (Høiland-Carlsen et al., 2011). Compared with Denmark, Norway is a thinly populated country. While Norwegian scenery is spectacular, transportation is difficult along narrow winding roads and a jagged coastline. Patients from the more remote parts of our health region may travel for up to 5 h, often necessitating an overnight stay in Bergen. The majority of patients from the southernmost locations travel to Bergen by air.

Thus in Norway, the question of equal access to health care has a strong geographical component. To our knowledge, our study is the first to systematically examine the influence of the place of residence on access to advanced diagnostics at a regional centre. Our analysis revealed that patients from the southernmost health trust had approximately 30% less chance of obtaining a PET examination than the patients from the three northern health trusts (Fig. 4). We became aware of this geographic imbalance in our health region as early as 2010 and have tried to establish equal access to PET examinations by providing information and lectures to our clinical partners at Stavanger University Hospital as well as by prioritizing patients from distant locations when allocating appointments. However, the analysis over time shows that our efforts have only partially succeeded (Fig. 4). The reasons for this regional imbalance are difficult to ascertain. Geographical distance provides no sufficient explanation in the context of Western Norway. Travelling times from the northern parts of our own health region are considerably longer than airplane travel from

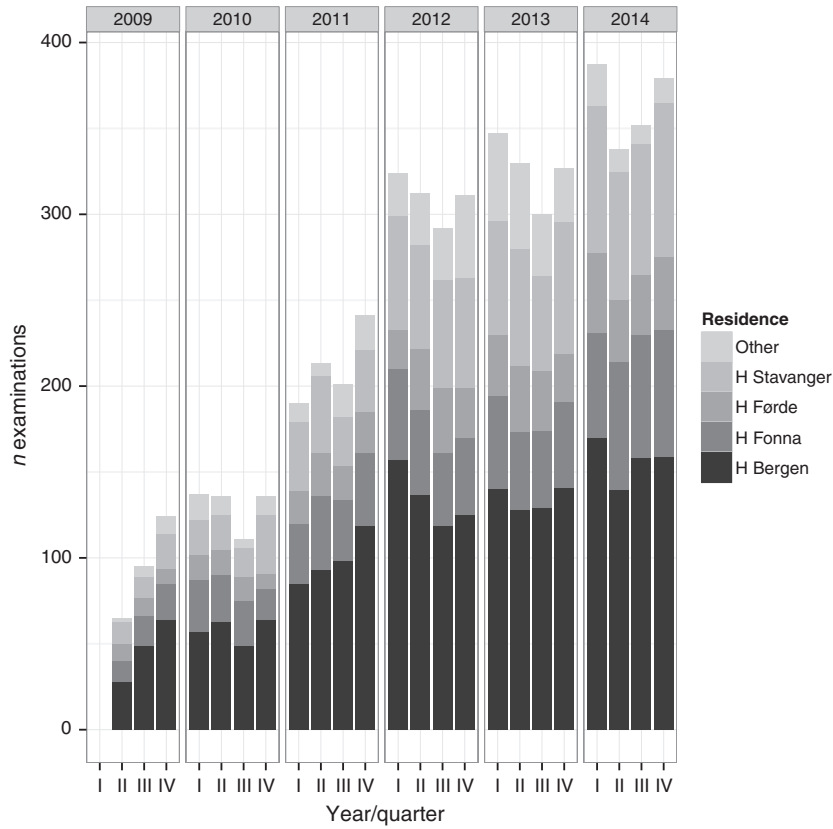


Figure 3 Number of PET examinations at Bergen PET-centre according to health trust.

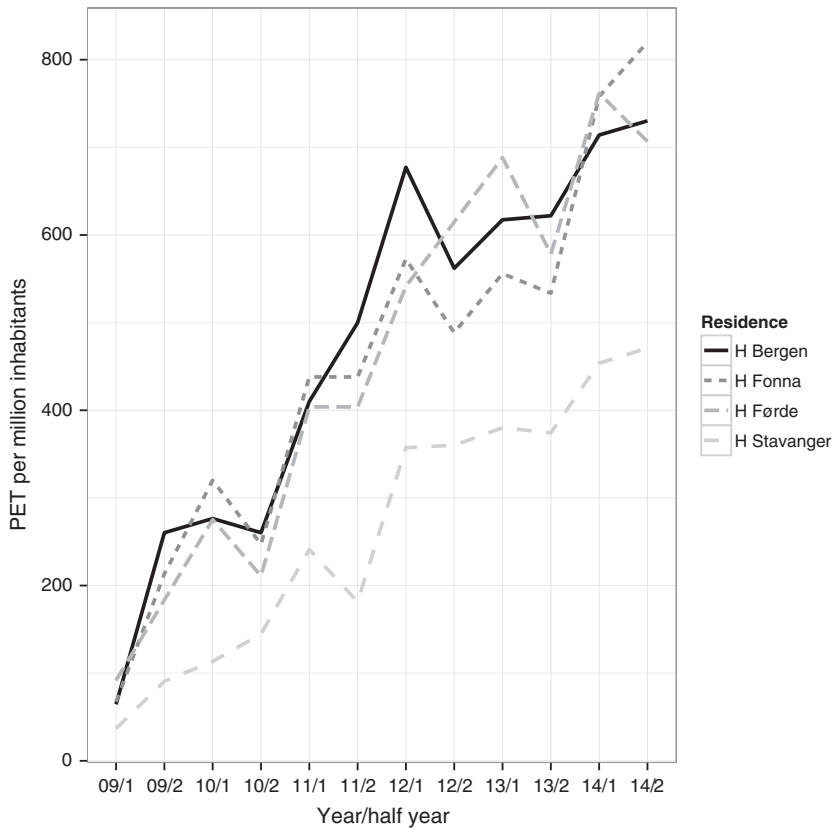


Figure 4 Number of PET examinations at Bergen PET-centre per one million inhabitants per half year for each of the four health trusts.

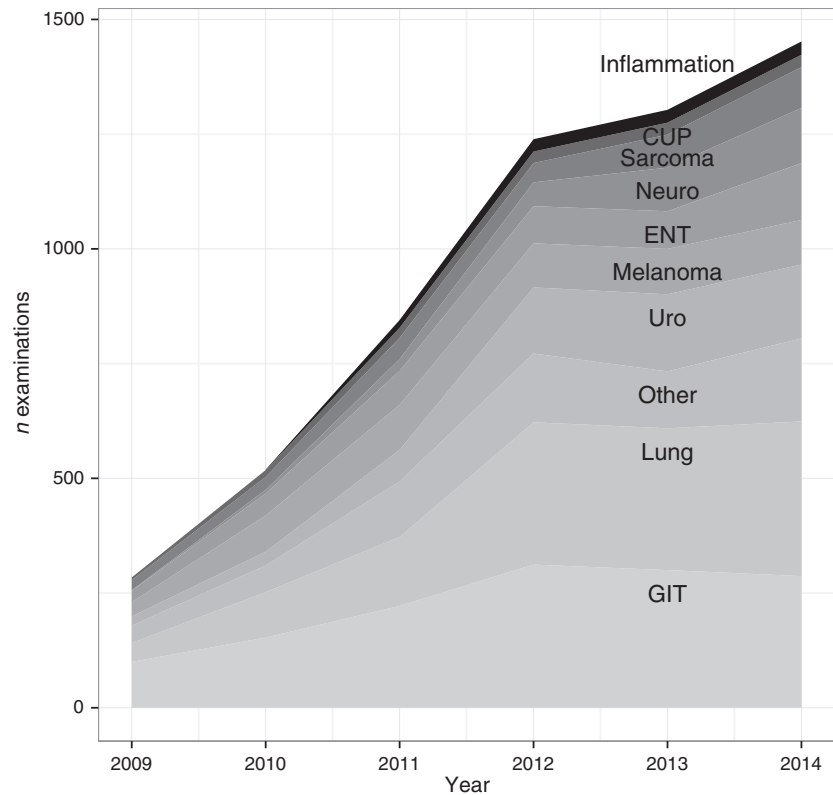


Figure 5 PET examinations at Bergen PET-centre per diagnostic group. CUP = Carcinoma of unknown primary, ENT = Ear, nose & throat and thyroid cancer, Uro = urology and gynaecological cancer, 'Other' = lymphadenopathy and suspected paraneoplastic disease, GIT = gastrointestinal tract cancer.

Stavanger. While a recent publication from Northern Norway concluded that long distance travel reduced the frequency of PET examination in lymphoma patients (Norum *et al.*, 2015), we found an inverse correlation between length of travel and use of PET in sarcoma patients treated in Bergen and in Oslo in a recent national population-based survey (Johnsen *et al.*, 2015). The most probable reason is thus a different referral pattern at Stavanger University Hospital. Whether PET referrals are restricted because of budgetary concerns is difficult to surmise. It will be interesting to see if the use of PET across the Western Health region will equalize when Stavanger University Hospital establishes its own PET-scanner late in 2016.

Several other hospitals outside the Western Health Region have begun to establish their own PET scanners. A political signal that uncontrolled development of PET capacity is not desired, may be the cut in the reimbursements for PET examinations for outpatients from approximately € 1400 to € 600 in summer 2014 (Directive for reimbursement for health services, 2014). Given the thin population density and the necessity of transporting radionuclides by air, small decentralized PET units are difficult to run efficiently in Norway. Our data show that a single centralized PET facility can serve a wide area, providing patients equal access to advanced health care.

Considering the wide spectrum of PET examination frequencies between countries like Japan and Denmark and the rest of Europe, it is difficult to ascertain in how far PET at our centre meets the clinical demand. More than 95% of all patients get appointments within the time frame set by the

referring physician. The plateau in examination numbers for gastrointestinal cancer, lung cancer and malignant melanoma since 2013 indicates that the clinical demand is met for these indications, at least in the context of current therapies. However, examination numbers continue to rise for most other diagnostic groups, and we are planning to scale up our production in the near future.

Limitations

(i) The study did not examine patient outcomes. While follow-up information for patients residing in the Bergen Health Trust would have been available through the electronic patient journal (EPJ), routine access to the EPJ in the other three trusts from our hospital is blocked. Outcome analysis would thus have introduced bias into our survey. (ii) For similar reasons, we did not attempt to evaluate the quality of referral practice in the different health trusts. (iii) Detailed analyses of the frequency of PET examinations between municipalities are limited by the wide variation in population size ranging from 215 (Utsira) to 271949 (Bergen). (iv) We cannot provide data on the lag time between referral and the actual PET examination for patients from the different health trusts. Although the information is stored in the department's RIS, this information cannot be retrieved. The lack of a suitable analysis module prompted us to develop our own solution under MDCake. (v) We have no data on how many patients from the Stavanger Health Trust have undergone PET-exami-

nations at other institutions than our own PET centre, but Stavanger University Hospital confirms that the number is low.

Conclusion

Centralized PET in the Western Norwegian health region meets the current clinical demand for patients resident in the three Northern health trusts while there was a relative under-

use of PET in the most Southern health trust. Access to specialized health care should be monitored routinely in order to identify inequalities in referral patterns and resource utilization.

Conflicts of interest

The authors have no conflicts of interest.

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