



Current Perspective

Towards better implementation of cancer screening in Europe through improved monitoring and evaluation and greater engagement of cancer registries



Ahti Anttila^{a,*}, Stefan Lönnberg^{a,b}, Antonio Ponti^c, Eero Suonio^d, Patricia Villain^d, Jan Willem Coebergh^{e,f}, Lawrence von Karsa^d

^a Finnish Cancer Registry, Helsinki, Finland

^b Cancer Registry of Norway, Oslo, Norway

^c CPO Piemonte and AOU 'City of Health and Science', Turin, Italy

^d International Agency for Research on Cancer, Lyon, France

^e Eindhoven Cancer Registry, Comprehensive Cancer Centre the Netherlands, Eindhoven, The Netherlands

^f Department of Public Health, Erasmus MC University, Rotterdam, The Netherlands

Received 19 June 2014; received in revised form 21 October 2014; accepted 23 October 2014

Available online 4 December 2014

KEYWORDS

Epidemiology
Cancer prevention
Cancer screening
Cancer registration
Evaluation
Monitoring
Quality assurance

Abstract Proposals to improve implementation, monitoring and evaluation of breast, cervical and colorectal cancer screening programmes have been developed in a European project involving scientists and professionals experienced in cancer registration (EUROCOURSE). They call for a clear and more active role for cancer registries through better interfaces with cancer screening programmes and adapting data contents of cancer registries for evaluation purposes. Cancer registries are recognised as essential for adequate evaluation of cancer screening programmes, but they are not involved in screening evaluation in several European countries. This is a key barrier to improving the effectiveness of programmes across Europe. The variation in Europe in the implementation of cancer screening offers a unique opportunity to learn from best practices in collaboration between cancer registries and screening programmes. Population-based cancer registries have experience and tools in collecting and analysing relevant data, e.g. for diagnostic and therapeutic determinants of mortality. In order to accelerate improvements in cancer control we argue that cancer registries should take co-responsibility in promoting effective screening evaluation in Europe. Additional investments are vital to further development of infrastructures and activities for screening evaluation and monitoring in the national settings and also at the pan-European level. The EUROCOURSE project also aimed to harmonise implementation of the European quality assurance guidelines for cancer screening programmes across Europe through standardising routine data collection

* Corresponding author at: Unioninkatu 22, FI-00130 Helsinki, Finland. Tel.: +358 503809514; fax: +358 91355378.
E-mail address: ahti.anttila@cancer.fi (A. Anttila).

and analysis, and definitions for key performance indicators for screening registers. Data linkage between cancer and screening registers and other repositories of demographic data and cause of death and where available clinical registers is key to implementing the European screening standards and thereby reducing the burden of disease through early detection. Greater engagement of cancer registries in this collaborative effort is also essential to develop adequate evaluation of innovations in cancer prevention and care.

© 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

1. Introduction: the challenge

Detection of cancer in its early stages in combination with prompt, appropriate treatment has become an important element in cancer control in recent decades. The aim of early detection is to reduce mortality and other serious consequences of advanced disease. In the case of cervical or colorectal cancer screening, incidence can also be reduced. Reduction of mortality may be accomplished if earlier treatment improves life expectancy, loco-regional control of disease and quality of life and/or permits equally effective therapy with fewer side-effects (Fig. 1). Universal access to prompt and effective diagnosis and treatment is a key to achieve the potential impact of early detection of cancer [1]. The concept of early detection of cancer has evolved since the 1968 report of the World Health Organisation (WHO) [2].

These widely acknowledged principles have been further modified through experience gained from implementation of population-based cancer screening programmes [3] recommended for bowel, breast and cervical cancer screening by WHO [4] and the European Union [5], provided the services are comprehensive and of high quality.

To achieve maximum benefits with minimum health risk, quality must be ensured at every step in the cancer screening process, including:

- identification and personal invitation of each eligible individual;
- performance of the screening test, examination or procedure;
- diagnostic work-up of people with detected abnormalities;
- when indicated, treatment, surveillance and aftercare.

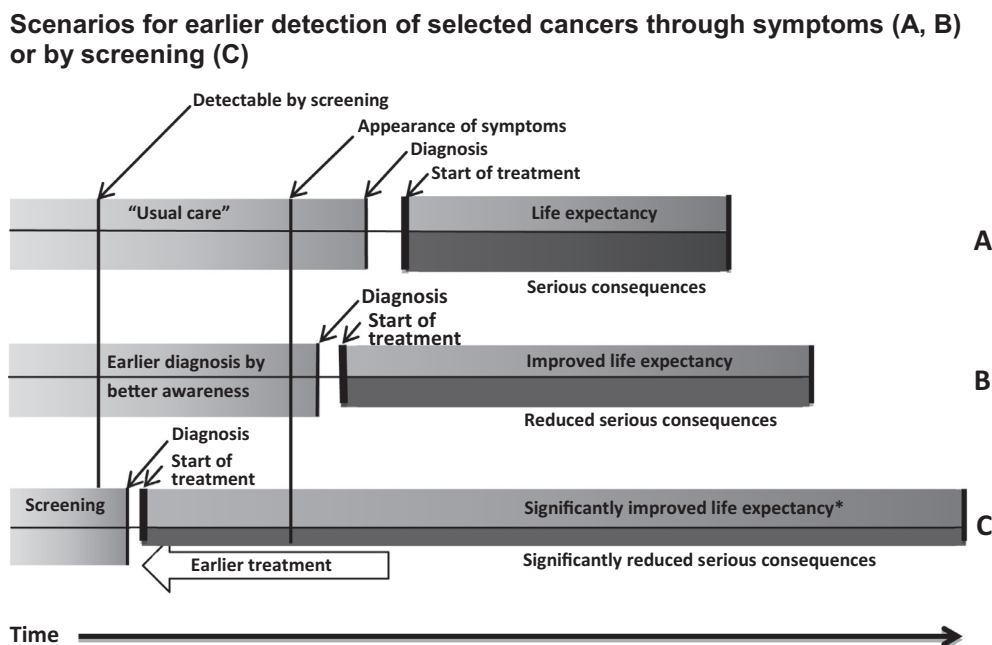


Fig. 1. Scenarios for Early detection of selected cancers through symptoms (A and B) or by screening (C). (A) Time intervals between appearance of symptoms, diagnosis, and start of treatment of a cancer can be weeks to months, and depend upon access to specialised care. (B) Earlier diagnosis and treatment of some cancers due to better awareness of symptoms may increase life expectancy and reduce serious consequences of the disease, especially with good access to treatment. Some over-diagnosis may also occur. (C) Before symptoms appear, screening in people at-risk leads to even earlier detection and treatment of some cancers, albeit with some over-diagnosis; but with an increased life expectancy and less serious sequels of the cancer, provided screening services are adequate. Ideally, the intervals between positive screening results or the appearance of symptoms, and diagnosis and the start of treatment of cancer should be as short as possible. Well-organised screening programmes can shorten the interval between diagnosis and start of treatment by prompt referral to qualified clinical units. They also provide an organisational framework for implementation of quality assurance that helps improve the benefits and limit the harms of screening, such as complications of treatment and over-diagnosis. Source: (1), adapted from the Inaugural address of Professor Harry de Koning; Rotterdam, the Netherlands: Erasmus MC, 2009.

In practice, the process of screening is much more complex than the steps outlined above. Throughout the process, balanced information must be provided to participants and programme owners on the benefits and harms of the services provided. This information must be based on systematic monitoring and evaluation that takes into account the complexity of the screening process.

In the following, the term ‘cancer registry’ is used to refer to the institution managing the databases (‘cancer register’) on the occurrence of cancer in the region served by the registry. The term ‘screening registry’ is used to refer to the institution managing the databases (‘screening register’) required for the documentation of the screening programmes and services. In practice, the same institution may manage both registers, or more than one institution may be responsible for the collection, checking and storage of some or all of the data in these registers. It is essential that these registries are not only responsible for managing the databases, but also for the interpretation and reporting of results and are engaged in the design of studies, in evaluation of screening, use of data for scientific purposes and in assuring that high quality data is available to other researchers for further investigation.

To achieve an appropriate balance between harm and benefit, comprehensive multidisciplinary guidelines for quality assurance in cancer screening have been developed [6–9]. They include monitoring of organisational, technical and professional performance and evaluation of impact as integrated parts of cancer screening programmes. Application of these key components across Europe has been limited to date, however [10,11], preventing opportunities to exchange experience between programmes. The main barriers to this progress have been:

- underdeveloped standards for documentation and reporting of cancer screening programmes;
- lack of an appropriate mandate, sustainable institutional infrastructure and adequate resources for systematic collection, analysis and reporting of the monitoring and evaluation data and results;
- wide variation in application of standards at national and/or regional level.

Therefore, scientists and professionals experienced in monitoring and evaluation of cancer screening collaborated in a European project (EUROCOURSE) [12] and designed a series of recommendations for data interfaces between cancer registries, screening programmes and other information sources. The present paper provides an overview of the data items and key performance indicators that cancer screening registries should collect, or have access to for standardised, regular monitoring at the regional, national and European level. It also reports the additional information to be acquired by and from

population-based cancer registries that is essential in improving the quality and effectiveness of cancer screening. Cancer registries are increasingly involved in assessing progress against cancer [13] and need to improve their capacity to assess the impact of cancer screening on the overall burden of cancer. Endorsement and implementation of the present suggestions to improve registration practices will be crucial to the success of these efforts in Europe and other continents.

2. Approach followed

Systematic review of the relevant standards, protocols and other recommendations in the European guidelines for quality assurance in breast, cervical and colorectal cancer screening was performed by an expert working group (see Acknowledgement) [6–9]. Additional relevant information was derived from the results of the activities of the work groups on registration of cancer screening in the former EU-funded project “European Network for Information on Cancer” (EUNICE) [14,15], and relevant recommendations of the European Network of Cancer Registries (ENCR) [16]. Based on these reviews, joint recommendations to improve the capability of cancer registries were developed. The potential of registries to improve the balance between benefit and harm of screening was also examined by reviewing the current knowledge from trials on lung and prostate cancer screening. Key results and conclusions for future improvement are publicly available [17] and have been recently used to update the European guidelines for quality assurance in cancer screening and diagnosis [8].

3. Considerations and recommendations

3.1. European data set for monitoring cancer screening

One of the key objectives of cancer screening registries is to monitor performance of cancer screening programmes and services by collecting, storing and reporting the information needed to support effective management and to assess services. These activities require a comprehensive data matrix that includes:

- description of the organisational settings delivering the screening services,
- characteristics or events that each variable describes,
- relevant coding standards for the data items underlying each variable.

The matrix should be used to continuously generate reports using standard sets of indicators for monitoring performance of screening programmes. The recommended short and long-term indicators for each target cancer (Tables 1–3) refer to screening protocols commonly used in Europe in 2010–2012 and also later years:

- mammography for breast cancer,
- cytology (pap) testing for cervical cancer,
- guaiac-based (gFOBT) or immunochemical (FIT) faecal occult blood test for colorectal cancer.

Indicators specific to other validated screening protocols are available for sigmoidoscopy for colorectal cancer [9] or are being developed, such as for primary Human Papillomavirus (HPV) testing in a cervical cancer screening programme.

Screening registries should also have access to information on any relevant diagnostic tests and treatments, i.e. also if they are performed outside of the programme [6]. Otherwise it is not possible to effectively manage the factors impacting on the outcome and cost-effectiveness of the screening programme. In addition the opportunity to avoid unnecessary testing outside the screening programme and thereby strengthen societal and health-economic benefits of quality assured screening programmes cannot be fully exploited without full information about relevant diagnostic tests and treatments outside the programme. Use of screening services outside

the population-based programme and policies permitting such use, still constitute a major barrier to achieving appropriate and cost-effective services in several countries. Tables 1–3 provide only a few examples of treatment indicators, as screening programmes should liaise with specialist clinical units for appropriate quality assurance of screen-detected as well as of clinical cases [18].

The screening registers should also record whether the test was performed in opportunistic screening, or due to clinical indication or management. They should also maintain accessible, complete records giving basic descriptions of the various data sources, coding structures and programme policies, and any other relevant data structures; including data generated by linkages.

Detailed examples of individual-level coding structures in use with screening registries to record the data needed to generate the variables and produce the indicators for each target cancer are publically available as one of the final products of the EURO COURSE project (see annexes 1–3 at [17]). For completeness and accuracy, the screening database must include indexing throughout all episodes (i.e. from test to recommenda-

Table 1

Description of performance indicators to be generated for European monitoring data on *breast cancer screening*.

Indicator	Numerator	Denominator
Extension by screening programme	N target population within the area with the organised screening programme	N of population with corresponding age and gender within the whole country
Coverage by invitation	N women invited during time frame	N women in target population
Coverage by examination	N women screened during time frame	N women in target population
Participation rate	N women invited and screened in episode	N women invited in episode
Further assessment rate	N screened and referred to further assessment	N screened
Compliance with further assessment	N participated in further assessment	N referred to further assessment
Technical repeat rate	N with a recall for technical reasons	N screened
Intermediate mammography rate	N screened out of sequence with the screening interval	N screened
Referral to treatment rate	N referred to surgery or to neo adjuvant therapy or inoperable cancer	N screened
B/M ratio	N with benign histological diagnosis	(ratio) N with histologically confirmed in situ or invasive cancer
Cancer detection rate (in situ included)	N with histologically confirmed in situ or invasive cancer	N screened
Ductal carcinoma in-situ (DCIS) detection rate	N with DCIS	N screened
Invasive cancer detection rate (invasive)	N with invasive breast cancer	N screened
Benign biopsy rate	N with benign histology	N screened
Small invasive cancers as proportion of invasive cancers	N with invasive cancer with pT 1A or 1B	N with invasive cancer
Node negative cancers/total cancers screen-detected	N with lymph nodal status negative	N with invasive cancer
Stage II + breast cancers/total cancers screen-detected	N with pTNM stage IIA to IV	N with invasive cancer
Stage II + breast cancers/total screened women	N with pTNM stage IIA to IV	N screened
Interval cancer	Cancer in screen negatives or episode negatives during the interval	
Conservative therapy (DCIS)	N with DCIS with breast conserving Surgery	N with DCIS operated
Conservative therapy (invasive)	N with invasive cancer with breast conserving surgery	N with invasive cancer
Conservative therapy (pT1)	N with pT1 invasive cancer with breast conserving surgery	N with pT1 invasive cancer

Table 2
Description of performance indicators to be generated for European monitoring data on *cervical cancer* screening.

Indicator	Numerator	Denominator
Extension by screening programme	N target population within the area with the organised screening programme	N of population with corresponding age and gender within the whole country
Coverage by invitation	N women invited during time frame	N women in target population
Coverage by examination	N women screened during time frame	N women in target population
Compliance to invitation	N invited and screened women in episode	N invited women in episode
Incidence of fully invasive cancer in unscreened and underscreened women	N fully invasive cancers detected in women not screened within interval	N person-years of women not screened for interval
Distribution of screened women by the results of cytology	N of women with each cytological diagnosis	N women screened in programme
Referral rate for repeat cytology	N screened women recommended for repeat screening after shorter interval	N women screened in programme
Compliance with referral for repeat cytology	N women screened after shorter interval	N women recommended for shorter interval
Referral rate for colposcopy	N women referred for colposcopy	N women screened in programme
Positive predictive value (PPV) of referral for colposcopy	N women with histologically confirmed CIN1+/CIN2+/CIN3+	N women with colposcopy
Test specificity	N screened women not referred for colposcopy	N screened women with no CIN1+/CIN2+/CIN3+
Detection rate by histological diagnosis	N screened women with each histological diagnosis	N women screened in programme
Cancer incidence after normal cytology	N screened women with fully invasive cancer within interval after normal test	N person-years of women with normal test for interval
Compliance to referral for colposcopy	N screened women who attended colposcopy	N women referred for colposcopy
Treatment of intraepithelial lesions	N women with treated screen-detected lesions CIN1/CIN2/CIN3	N women with screen-detected lesions CIN1/CIN2/CIN3
Proportion of women hysterectomised on screen-detected intraepithelial lesions	N women hysterectomised on histological CIN1/CIN2/CIN3	N women with histological CIN1/CIN2/CIN3
Incidence of non-screen-detected fully invasive cancer after abnormal cytology	N cases of invasive cancer after abnormal cytology	N person-years of screened women after abnormal cytology

Table 3
Description of performance indicators to be generated for European monitoring data on *colorectal cancer* screening.

Indicator	Numerator	Denominator
Extension by screening programme	N target population within the area with the organised screening programme	N of population in corresponding age groups within the whole country
Invitational coverage	N invited during time frame	N eligible in target population
Coverage by examination	N screened or tested during time frame	N eligible in target population
Compliance to invitation (uptake rate)	Screened	Invited
Rate of inadequate tests	Inadequate	Screened
Rate of test positives	Positive test result	Screened
Referral rate to colonoscopy after positive test	Referred	N with a positive test result
Compliance to colonoscopy	Colonoscoped	Referred
Rate of complete colonoscopies	Complete colonoscopies	Total colonoscoped
Biopsy rate	Biopsy taken	Colonoscoped
Lesion detection rate	N with at least one lesion	Screened
Adenoma detection rate	N with at least one adenoma	Screened
Advanced adenoma detection rate	N with at least one advanced adenoma	Screened
Cancer detection rate	N with at least one cancer	Screened
PPV for detection of lesions	N with at least one lesion	N with colonoscopy
PPV for detection of adenoma	N with at least one adenoma	N with colonoscopy
PPV for detection of advanced	N with at least one advanced adenoma	N with colonoscopy
PPV for detection of cancer	N with at least one cancer	N with colonoscopy
Endoscopic complications	N with complication	N with colonoscopy
Interval cancer	Cancer in screen negatives or episode negatives during the interval	

tions and related management). This is facilitated by the use of unique personal identifiers to compile the full information of an individual over multistep screening episodes, and to link this information to other data

sources in health-care. The internal and external quality of the screening registers needs to be regularly checked by the responsible staff and errors continuously corrected. Final, comprehensive quality control of

information about cancer cases and other data items included in the cancer register should be conducted routinely by the cancer registry. Screening registries need to pass their information to cancer registries to enable this quality control, and in return will be able to utilize reliable data on cancers. The multiple data sources may also permit more accurate differentiation between invasive and precancerous lesions throughout the diagnostic process. The following data items in screening registers are generally not included in the cancer registry domain: results of the screening test and related assessment of abnormalities detected, and treatment, and thus systematic data quality control procedures are needed also in the screening registers for these items.

3.2. Collection and linkage of screening registry data

The data collected by screening registries should permit generation of aggregated performance indicators for comparative monitoring at the European level (Tables 1–3). Every cancer screening registry should adopt standard collection procedures that utilise electronic data, coded according to standard practice within the respective health-care system. The data input can be condensed and processed further by the screening registry in order to generate the variables needed to produce the standard performance indicators.

Data essential to monitoring and evaluation of cancer screening programmes are not only stored in cancer registries and screening registries. It must also be obtained by linkage of these with population registers, cause of death registers, and – where available – clinical registers of diagnostic and treatment services such as hospital and outpatient registers. Relevant information must also be obtained from vaccination registers (human papilloma virus, HPV) and biomaterial archives. Unique personal identifiers should be used in all of the registers to permit effective linkage for data access and to control data quality. For example, cause of death statistics may be less accurate for a given cancer site than cancer registry data because the latter utilise multiple data sources.

3.3. Innovations in cancer registration to improve evaluation of screening

In the context of cancer screening, the role of the cancer registry is to collect, analyse and report information needed to reliably assess the impact of the programme on the burden of disease in the population. Ultimately disease-specific mortality, but, especially for cervical or colorectal cancer screening, disease- and age-specific incidence must also be evaluated. The evaluation organisation also needs information on those adjuvant and palliative treatments that lower cancer mortality or improve quality of life of cancer patients. The additional data and legal framework that are needed are outlined

below. The suggestions reported here should be incorporated into the standards and procedures adopted by the cancer registration community.

3.3.1. Reporting pre-cancerous lesions

Data on pre-cancerous lesions are needed to weigh the achieved benefit of screening in the light of potential harm by detecting and treating pre-cancerous lesions, many of which would not progress to cancer for a long time if left untreated. Comprehensive screening registers are the primary source for these data in combination with the cancer registry.

Cancer registries should record cases of high-grade intraepithelial cervical dysplasia and in situ cancers (CIN3/AIS). Micro-invasive cervical carcinoma and CIN3/AIS with separate codes in ICD-O-3 classification of morphology should therefore be recorded separately (from each other or from fully invasive cancer). Screen-detected cancers in the micro-invasive phase appear to be better treatable and result in lower mortality than fully invasive cancers. In addition, anal, vaginal, and vulvar intraepithelial dysplasia (AIN3, VAIN3, VIN3) are pre-invasive lesions that may be affected by screening activities, and are now reported only to some cancer registries.

In situ carcinoma of the breast should also be recorded in the cancer registry. Ductal carcinoma in-situ (DCIS) of the breast is included in ICD-O-3 and should be separately tabulated from invasive cancer (see recommendation below on multiple primaries). Current cancer registry practices vary with regard to the choice of the date of DCIS or of the invasive cancer when diagnosed within a short period of time.

For colorectal cancer, recording of advanced adenomas is essential for the evaluation of cancer screening programmes because such data of non-attenders are not available in screening registries. There is also a need to standardise the definition of an advanced adenoma for registration purposes as the existing Systematized Nomenclature of Medicine (SNOMED) or WHO classifications do not define these lesions adequately. We suggest to adopt the criteria used in the European quality assurance guidelines for colorectal cancer screening that define an advanced colorectal adenoma as one that is either ≥ 10 mm or contains high-grade mucosal neoplasia or a villous component [19]. As for other pathologic criteria such as villous morphology, there is no universal agreement to include them in the registration.

3.3.2. Validation of the mode of detection

Reporting the mode of detection, i.e. the screening status at the time of detection:

- before first or after last invitation,
- invited, but not attended,
- screen-detected,
- interval cancer, and
- not invited

is important to effectively monitor performance and provides information that helps to explain the extent to which a screening programme impacts on the burden of disease in the target population and the population as a whole. Mode of detection is a reliable variable only if produced through systematic linkage of screening and cancer registers.

At the time of reporting the tumour to the cancer registry, the screening status of the cancer case may not be known. Linkage with the screening registry may therefore need to be performed over one or more full screening rounds. For practical reasons, linkages for assessing the mode of detection should be carried out by the screening programme monitoring system and the results should be made available for all cancer cases of the primary sites targeted by screening programmes also in the regular cancer registry statistics.

3.3.3. Consistent registration of incidence date

To assign an incidence date, consistent rules should be applied from the ENCR priority list [15]. Furthermore, the availability of subsequent dates in the assessment pathway is useful for quality assurance and related studies of cancer screening. Recording a minimum set of dates, e.g. first diagnostic visit, first diagnostic specimen, pathology report, and sources of such information will promote comparability of data between registries.

3.3.4. Multiple primaries

To permit effective screening evaluation, all primaries should be collected and coded as separate cancers. Only one of these primaries would be the “incident” case. In principle, this approach is consistent with the current ENCR recommendation, but some adjustment in detail is needed. For example, lobular and ductal breast carcinomas should be considered as different morphology, i.e. as separate cancer cases, in departure from the ENCR coding rule 3 of the A1.2 recommendations for coding multiple primaries. Synchronous or metachronous breast cancer in different breasts, even if of the same morphology, should also be recorded as multiple primaries.

DCIS may not only pose a problem due to the potential for multiple primaries. If DCIS is followed by invasive recurrence, the latter tumour becomes the incident cancer according to current coding rules. However, detection of DCIS is important information in the management of breast cancer, even if it is the first diagnosis. All DCIS should be recorded so that all cases can be included in further quality assurance databases for cancer screening programmes.

Concerning CIN/AIS and cervical cancer, in non-advanced cancers, areas of intraepithelial neoplasia usually coexist with areas of invasion. Not infrequently, a high-grade CIN is diagnosed on a punch biopsy and invasion is observed shortly thereafter on the Loop Electrosurgical Excision Procedure (LEEP)/conisation

specimen, suggesting that the cancer already existed when the biopsy was taken. However, CIN3 can of course progress to invasion if untreated, or even despite treatment. Plausibly, CIN3 should be registered separately if diagnosed over a certain time interval before cancer is detected and not if diagnosed afterwards.

3.3.5. TNM for coding the extent of disease

The ENCR recommends full TNM Classification of Malignant Tumours (TNM) and, if not available, a condensed TNM (coding the extent of disease). Full TNM Classification of Malignant Tumours, stage given by pathologic examination of a surgical specimen (pTNM) based on pathology reports on screen-detected cases should be the recording standard. Specifically for colorectal cancer, information on the depth of cancer invasion is more important than the size of the tumour. The former cannot be derived from the condensed TNM. In addition, the location of the tumour should be recorded according to ICD-0-3 topography. The full clinical TNM (cTNM) should be included in the cancer registry information as a separate code. Cancer registries should aim to record the exact size of screen-detected tumours in millimetres.

3.3.6. Ethical and legal framework for quality assurance

Availability of individual data in the cancer registry for linkage to data in the screening registry is crucial to quality assurance of the screening programme and other oncologic services. Developing the appropriate legal and technical framework for data collection and linkages is an important responsibility of any authorities responsible for screening programmes [20]. The legal frameworks for the different systematic registries in a given health care system are quite similar. If cancer registries have a comprehensive, official responsibility in the assessment of the quality of screening and clinical care, the legal and technical aspects should become less complicated than with separate evaluation systems.

4. Discussion

Considerable experience has gradually developed in Europe in successful implementation of population-based cancer screening programmes [6–9,14,21–23]. All of the EU countries have piloted or implemented or are currently in the process of planning implementation of at least one of the three recommended cancer screening programmes (breast, cervix or colorectal). Population-based organisation and implementation with quality assurance of every step in the screening process from invitation to testing, diagnosis, treatment and surveillance is the cornerstone of the recommended European approach [5,21,23]. Effective implementation begins with asking the right questions about the programme design, and includes development and testing

of a comprehensive population-based quality assurance system. This requires development of capacity to effectively monitor short- and medium-term professional and technical performance and to recognise changes in performance over time in order to continuously improve the screening service and to take corrective action, if necessary.

The expert working group that developed the present recommendations also pointed out the need for closer collaboration between screening programmes and population-based cancer registries, not only to effectively generate the requisite performance indicators, but also to interpret the data correctly. The direct exchange of information between the cancer registry and clinical specialists contacted to verify data can result in a better interpretation of data and improvements in clinical performance. Given the many years required to assess the impact of a screening programme on the population burden of cancer, current results of performance monitoring must be correlated with the future estimated results of evaluation studies. By the same token, assessment of the harms of screening, such as overdiagnosis and overtreatment – especially a problem when detection techniques become more sensitive – requires a similar approach, collaboration and data linkage. Continuous, effective monitoring of screening performance is therefore necessary for timely interpretation of the emerging results even when the long-term evaluation studies of cancer screening are not yet available for the particular programmes.

Whereas the health authorities in the EU member states have increasingly embraced the European policy of recommending population-based programmes for breast, cervical or colorectal cancer screening using evidence-based methods and following the European quality assurance guidelines [23], awareness has only recently been raised for the importance of investment in infrastructure for comprehensive performance monitoring and long-term impact evaluation of screening programmes. The supplement to the 4th edition of the European guidelines for quality assurance in breast cancer screening and diagnosis points out that successful implementation of effective cancer screening programmes requires significant resources for quality assurance i.e. 10–20% of total expenditure (see Box 1) [24,25]. This proportion is based on experience in implementing population-based cancer screening programmes in Europe. The lower end of the range is more applicable to very large, less complex programmes with substantial economies of scale. In the initial years, this proportion may be substantially higher due to the low volume of screening examinations compared with the situation after complete rollout of a nationwide programme. A substantial proportion of these resources is required for well-organised information systems, such as those

in use by screening registries and population-based cancer registries, to assure the quality of the screening service and appropriate action following a positive screening test; and to monitor performance and evaluate the impact of any screening programme [1,24]. Quality assurance also includes timely, prospective evaluations of modifications of existing programmes and piloting of new programmes. Adherence to these principles and recommendations is an ethical imperative to assure that the screening services delivered to the population are appropriate.

Nationwide, population-based registration of breast, cervical and colorectal cancer is not yet feasible in all of the EU member states. In 2012 cancer registry coverage of the combined European populations was somewhat more than 60%. Systematic evaluation of cancer control and quality of care remained modest, except in a few dedicated CRs. Respectively, evaluation of mass screening programmes was supported more or less routinely by only 44% of CRs. [26]. Comprehensive cancer screening registries with the capacity to regularly link and closely collaborate with the cancer registry are unfortunately an exception [27,28]. In a recent review of longitudinal cohort follow-up studies that linked a woman's screening history to cause of death, the authors estimated a reduction in breast cancer mortality by 25–31% for women invited for screening [29]. This study design was possible only using regional data from Denmark, Finland, Italy, Norway and Sweden [29,30]. Developing availability of data details and particularly also appropriate legal frameworks enabling screening-related public-health research activities utilising the register-based infrastructures [31,32] are crucial to the future development of European cancer registries. Evaluation of clinical and diagnostic quality irrespective of cancer screening is also very important, there are synergies with this area of research and evaluation of cancer screening programmes (see Box 2). Cancer registries are increasingly engaged in the assessment of the quality of care of those oncological services that are not involved in cancer screening. For the cancer sites targeted by cancer screening programmes, screening registries can provide a basis for developing the systematic population-based quality care registers. Evidence-based and quality-assured cancer screening can stimulate health systems to raise standards of care within and outside the programme; population-based screening also raises awareness of cancer symptoms among healthcare professionals and the general public. Training of professionals and quality assurance in diagnosis, staging and treatment in the screening programme have the potential to improve cancer prevention and care across the board. These factors, in combination are likely to have contributed to declines in mortality from cervical and breast cancers in countries or regions with ongoing population-based screening programmes.

5. Conclusions

Monitoring and evaluation are essential to quality assurance of population-based cancer screening programmes. Concerted investments are needed to develop data collection systems and to enable competent centres such as screening and cancer registries to collaborate in linking and analysing the requisite data.

Harmonised data collection and analysis, and regular exchanges of experience and results between programmes and competent evaluation centres at the regional, national and European level will accelerate improvement in cancer screening and thereby reduce the burden of breast, cervical and colorectal cancer in Europe. This support will also lay the foundation for future efforts e.g. if prostate or lung cancer screening become an option across Europe.

Population-based cancer registries have experience and tools in collecting and analysing relevant data for cancer prevention and diagnostic and therapeutic determinants of mortality. Greater engagement of cancer registries in monitoring and evaluation of cancer screening programmes is essential to improve the programmes and to permit better overall assessment of progress against cancer, taking into account changes in prevention and quality of treatment.

Box 1 Requirements for effective implementation of cancer screening programmes.

- Engagement of population-based registries for cancer, population, patient-clinical data and screening, all based on individual data,
- Commitment from responsible authorities and key stakeholders for quality assurance;
- Adequate legal and institutional support for quality assurance throughout the screening process including coordination, supervision and training, quality control of equipment, computerised information systems, and monitoring and evaluation;
- Supply of dedicated personnel and resources for provision of multidisciplinary screening services including testing, diagnosis, treatment, surveillance and palliative care and for quality assurance.
- Expenditure for quality assurance of 10–20% as estimated from costs of a fully established programme. This expenditure also includes sustainable funding for cancer and screening registries.

Box 2 Innovations in population-based cancer registries to ensure the quality of cancer screening programmes through monitoring and evaluation.

- Mandating and adequately resourcing cancer registries to accept co-responsibility for the quality and impact assessment of screening programmes.
- High quality recording of precancerous lesions:
 - high-grade cervical intraepithelial neoplasia, and in situ carcinoma of the cervix.
 - in situ carcinoma of the breast.
 - advanced colorectal adenomas, and colorectal polyps with high-grade dysplasia.
 - high-grade vaginal, vulvar and anal dysplasia.
- Recording mode of detection of cancer or precancer.
- Applying consistent rules to definition of incidence date and separate recording of multiple primaries (synchronous and metachronous), micro-invasiveness, TNM (pathological and clinical) and location.
- Using the whole information chain to evaluate the quality of the clinical pathway in the screening process. This might also enable national or regional screening registries to evolve into cancer-specific quality registries or become part of the cancer registry.

Conflict of interest statement

None declared.

Acknowledgements

EUROCOURSE was financed by the European Union through the 7th Framework Programme, LSSH-CT-2008-219453 (Europe against Cancer: Optimisation of the Use of Registries for Scientific Excellence in research).

The present report is based on the recommendations for cancer screening programmes, cancer registries, and other data providers and stakeholders, drafted during a series of meetings by an expert working group of representatives of mass screening evaluation and cancer registries: Ahti Anttila (chair), and Anssi Auvinen, Finland; Arkadiusz Chil, Poland; Harry de Koning and Jacques Fracheboud, The Netherlands; Lawrence von Karsa, IARC; Stefan Lönnberg (rapporteur) Finland/Norway; Nea Malila, Finland; Paola Pisani and Antonio Ponti,

Nereo Segnan, Guglielmo Ronco, Italy; Sven Törnberg, Sweden; Lydia Voti, IARC, now at EU JRC, Italy; Maja Primic Žakelj Slovenia.

The recommendations were discussed at a pan-European network meeting held in Warsaw in May 2010 funded by the European Union through the EURO-COURSE project ([FP7/2007-2013] under grant agreement No. 219453) and the European Cooperation on Development and Implementation of Cancer Screening and Prevention Guidelines (ECCG-ECN) grant agreement No. 2006322.

We thank Dr. Isabelle Soerjomataram from the IARC for the skilful editing of the manuscript.

References

- [1] von Karsa L, Dean PB, Arrossi S, Sankaranarayanan R. Screening – principles. In: Stewart BW, Wild CP, editors. World cancer report 2014. International Agency for Research on Cancer: Lyon; 2014. p. 322–9.
- [2] Wilson JMG, Jungner G. Principles and practice of screening for disease. Geneva, Switzerland: WHO; 1968 [Report No.: 34].
- [3] Lansdorp-Vogelaar I, von Karsa L. European guidelines for quality assurance in colorectal cancer screening and diagnosis. First Edition – Introduction. *Endoscopy* 2012;44(suppl. 3):SE15–30.
- [4] Action plan for implementation of the European strategy for the prevention and control of noncommunicable diseases 2012–2016. Copenhagen: WHO Regional Office for Europe; 2011.
- [5] Council of the European Union. Council recommendation of 2 December 2003 on cancer screening (2003/878/EC). *Off J Eur Union* 2003 (L 327): 34–8.
- [6] Arbyn M, Anttila A, Jordan J, et al., editors. European guidelines for quality assurance in cervical cancer screening – second edition. Luxembourg: Office for Official Publications of the European Communities; 2008.
- [7] Perry N, Broeders M, de Wolf C, Tornberg S, Holland R, von Karsa L, editors. European guidelines for quality assurance in breast cancer screening and diagnosis. Luxembourg: Office for Official Publications of the European Communities; 2006.
- [8] Perry N, Broeders M, de Wolf C, Tornberg S, Holland R, von Karsa L. (editors.) European guidelines for quality assurance in breast cancer screening and diagnosis. Fourth edition, supplements. Luxembourg: European Commission, Publications Office of the European Union; 2013.
- [9] Segnan N, Patnick J, von Karsa L, editors. European guidelines for quality assurance in colorectal cancer screening and diagnosis – first edition. Luxembourg: European Commission, Publications Office of the European Union; 2010.
- [10] Anttila A, von Karsa L, Aasmaa A, et al. Cervical cancer screening policies and coverage in Europe. *Eur J Cancer* 2009;45(15):2649–58.
- [11] Giordano L, von Karsa L, Tomatis M, et al. Mammographic screening programmes in Europe: organization, coverage and participation. *J Med Screen* 2012;19(suppl. 1):72–82.
- [12] <<http://www.eurocourse.org/>>.
- [13] Karim-Kos HE, de Vries E, Soerjomataram I, Lemmens V, Siesling S, Coebergh JW. Recent trends of cancer in Europe: a combined approach of incidence, survival and mortality for 17 cancer sites since the 1990s. *Eur J Cancer* 2008;44:1345–89. <http://dx.doi.org/10.1016/j.ejca.2007.12.015>.
- [14] Ronco G, Anttila A (editors). Cervical cancer screening in the European Union. 45 ed.; 2009. p. 2629–2722.
- [15] Hofvind S, Ponti A, Patnick J, Ascunce N, Njor S, Broeders M, et al. False-positive results in mammographic screening for breast cancer in Europe: a literature review and survey of service screening programmes. *J Med Screen* 2012;19(suppl. 1):57–66.
- [16] <<http://www.enrc.eu/index.php/activities/recommendations>>.
- [17] <<http://screening.iarc.fr/doc/RecommendationsWG.pdf>>.
- [18] Del Turco MR, Ponti A, Bick U, et al. Quality indicators in breast cancer care. *Eur J Cancer* 2010;46(13):2344–56.
- [19] Quirke P, Risio M, Lambert R, von Karsa L, Vieth M. European guidelines for quality assurance in colorectal cancer screening and diagnosis. first edition – quality assurance in pathology in colorectal cancer screening and diagnosis. *Endoscopy* 2012;44(suppl. 3):SE116–30.
- [20] Andersen MR, Storm HH; on behalf of the EURO-COURSE Work Package 2 Group. Cancer registration, public health and the reform of the European data protection framework: abandoning or improving European public health research? *Eur J Cancer* 2013. pii: S0959-8049(13)00845-9. doi: 10.1016/j.ejca.2013.09.005.
- [21] Lyng E, Tornberg S, von Karsa L, Segnan N, van Delden JJ. Determinants of successful implementation of population-based cancer screening programmes. *Eur J Cancer* 2012;48(5):743–8.
- [22] Malila N, Senore C, Armadori P. European guidelines for quality assurance in colorectal cancer screening and diagnosis. First edition – Organisation. *Endoscopy* 2012;44:SE31–48.
- [23] von Karsa L, Anttila A, Ronco G, et al. Cancer Screening in the European Union. Report on the implementation of the council recommendation on cancer screening – first report. Luxembourg: European Commission; 2008.
- [24] Perry N, Broeders M, de Wolf C, Tornberg S, Holland R, von Karsa L. Executive summary. In: Perry N, Broeders M, de Wolf C, Tornberg S, Holland R, von Karsa L (editors). European guidelines for quality assurance in breast cancer screening and diagnosis. Fourth edition, supplements. Luxembourg: European Commission, Publications Office of the European Union; 2013. p. xiii–xx.
- [25] von Karsa L, Anttila A, Primic-Zakelj M, et al. Annex 1a: Stockholm statement on successful implementation of population-based cancer screening programmes. In: Perry N, Broeders M, de Wolf C, Tornberg S, Holland R, von Karsa L (editors). European guidelines for quality assurance in breast cancer screening and diagnosis. Fourth edition, supplements. Luxembourg: European Commission, Publications Office of the European Union; 2013. p. 123–8.
- [26] Siesling S, Louwman WJ, Kwast A, van den Hurk C, O’Callaghan M, Rosso S, et al. Uses of cancer registries for public health and clinical research in Europe: results of the ENCR survey among 161 population-based cancer registries during 2010–2012. *Eur J Cancer* 2014. pii: S0959-8049(14)00816-8. doi: 10.1016/j.ejca.2014.07.016 [Epub ahead of print].
- [27] Ferlay J, Steliarova-Foucher E, Lortet-Tieulent J, Rosso S, Coebergh JW, Comber H, et al. Cancer incidence and mortality patterns in Europe: estimates for 40 countries in 2012. *Eur J Cancer* 2013;49(6):1374–403.
- [28] Arnold M, Karim-Kos HE, Coebergh JW, Byrnes G, Anttila A, Ferlay J, et al. Recent trends in incidence of five common cancers in 26 European countries since 1988: analysis of the European Cancer Observatory. *Eur J Cancer* 2014(13). <http://dx.doi.org/10.1016/j.ejca.2013.09.002> [pii: S0959-8049(13)00842-3].
- [29] Njor S, Nyström L, Moss S, Paci E, Broeders M, Segnan N, et al. Breast cancer mortality in mammographic screening in Europe: a review of incidence-based mortality studies. *J Med Screening* 2012;19(suppl. 1):33–41.
- [30] Weedon-Fekjær H, Romundstad PR, Vatten LJ. Modern mammography screening and breast cancer mortality: population study. *BMJ* 2014;17(348):g3701. <http://dx.doi.org/10.1136/bmj.g3701>.

- [31] Siesling S, van den Hurk C, Louwman M, van den Eijnden J, Lemmens V, van de Poll L, et al. Population-based cancer registration in Europe anno 2014: from backroom secret cancer intelligence service to programmatic visible 'registree' with fruits from roots. *Eur J Cancer* 2014 [in press].
- [32] Andersen MR, Storm H, on behalf of the Eurocourse Work Package 2 Group. Cancer registration, public health and the reform of the European data protection framework: abandoning or improving European public health research? *Eur J Cancer* 2013 [pii S0959-8048(13) 00845-9].