Can a structured electronic medical record with decision-making support improve nursing home quality?

Healthcare administration through structured records

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Scientific environment

This thesis was compiled entirely during the time the candidate was hired as chief physician (specialist in internal medicine and geriatrics) at the **Løvåsen Educational Nursing Home, Bergen County, Bergen, Norway**. At times he has had partial leave of absence from his position to work on this project, which has been made possible by research grants from the **Norwegian Research Council, Health and Care Programme.**

The project has been affiliated academically with the **Norwegian University of Science and Technology (NTNU) in Trondheim, the Norwegian Centre for Electronic Patient Record**s, and the project owner at NTNU has been Professor Anders Grimsmo MD, PhD, **Department of Public Health and General Practice (NTNU).** The agreement with the Research Council has been associated with NTNU.

NTNU has had an agreement with Bergen Municipality concerning the implementation of the project. The candidate has been the project manager for NTNU.

The candidate has a formal PhD connected with the **Department of Public Health and Primary Health Care, University of Bergen, Norway** (from Jan. 1, 2013; department of Global and Public Health). The supervisors in this regard have been Dr Jonn Terje Geitung MD, PhD, MHA, chief physician, and Professor Geir Egil Eide CandReal, DrPhilos, who has overseen statistical guidance of the project. He is also affiliated with the **Centre for Clinical Research, Haukeland University Hospital, Bergen, Norway.**

Technological developments have been carried out by Magne Rekdal MD, owner and general manager of **Emetra AS**, partly with a grant from the Norwegian Research Council.

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Abstract

Background: Nursing homes face challenges in the coming years due to the increased number of elderly. A new law in force from Jan 2012 ("Samhandlingsreformen") places more responsibilities on the counties running the nursing homes. Quality will come under pressure, expectations of services will rise and clinical complexity will grow. New strategies are needed to meet this situation. Modern clinical information systems with decision-making support may be part of that. In addition, knowledge about the prevalence of clinical conditions among long-term patients in nursing homes is poor, and research on this population is needed.

Objectives: We wished to define the clinical and practical parameters needing to be improved among long-term patients in nursing homes, which could then be used as endpoints in an intervention study.

We then wanted to test if a structured electronic medical record system with decision-making support improved the quality of the endpoints.

Methods: First we performed a literature search study on structured medical records. We then developed a full-scale, semi-structured, interdisciplinary electronic medical record system with extensive decision support options and conducted four studies, three to define endpoints and gain medical knowledge about the nursing home population: "Hospitalizations from nursing homes", "Psychoactive drugs in 7 nursing homes" and "Atrial fibrillation and heart failure in nursing homes". Then we performed an intervention study, "Can electronic tools improve nursing home quality?"

Results: Installing the information system in seven new nursing homes proved easier than expected**.** After four months' training the nursing homes switched to the new system and used it as the only medical record system on a daily basis for the next 12 months (February 2008 – February 2009).

We discovered a seriously low warfarin treatment rate (14%) to patients with atrial fibrillation (N = 90), considerable treatment rate differences between institutions regarding use of neuroleptics (18 – 55%) and the proportion of patients not weighed for the last 30 days was 72.6%.
The proportion of patients taking neuroleptics was reduced from 33.0% to 21.5% (N = 183 before/205 after, chi-square test, p = 0.015), i.e. a difference of 11.5% (95% CI: 2.3 to 20.6%). Warfarin increased from 3.0% to 9.8% (p = 0.013), i.e. a difference of 6.8% (95% CI: 1.6 to 12.1%). The internal controls did not change: use of digitoxin did not increase significantly (8.0% vs. 8.5%; p = 0.1), thyroxin was not reduced (10.0% vs. 8.6%, p = 0.765) and antidiabetics did not increase (10.0% vs. 10.5%; p = 0.996). The proportion of patients not weighed for the last 30 days was reduced from 72.6% to 16.0% (p < 0.001), i.e. a difference of 56.6% (95% (CI: 47.5 to 64.5%)).

Conclusions: There exist treatment differences among nursing homes. Research showing consequences for patients is pending. The electronic medical record system with integrated decision-making support may be a way to improve quality. The present material is too small

for firm conclusions however. The application should be tested in multiple medical settings, and may provide a route from pure economic to more scientific healthcare governance, as management data can be produced through daily work without time-consuming and costly additional projects and can be monitored electronically on a continuous basis. This may have relevance to New Public Management, which so far have had shortcomings regarding valid quality parameters. We introduce the idea of "health administration through structured records" (HATS).

List of publications

1. Krüger K, Jansen K, Grimsmo A, Eide G E, Geitung J T. "Hospital admissions from Nursing Homes: Rates and Reasons". Nursing Research and Practice. Volume 2011, Article ID 247623, 6 pages.
2. Krüger K, Folkestad M, Geitung J T, Eide G E, Grimsmo A. "Psychoactive drugs in seven nursing homes". Primary Health Care Research & Development. 2012; 13 (3); 244-254.
3. Krüger K, Sandli M, Grimsmo A, Eide G E, Geitung J T. "Atrial fibrillation and heart failure in seven nursing homes". Journal of Nursing Education and Practice. 2012; 2(4); 22-32.
4. Krüger K, Strand L, Geitung J T, Eide G E, Grimsmo A. "Can Electronic Tools Help Improve Nursing Home Quality?" ISRN Nursing. Volume 2011, Article ID 208142, 8 pages.

Expressions and abbreviations

ACEI	Angiotensin-converting enzyme inhibitors
AF	Atrial fibrillation
ANOVA	Two-way analysis of variance
ARB	Angiotensin receptor blockers
ATC	The anatomical therapeutic chemical classification system
BP	Blood pressure
CHADS2	Prediction rule for estimating the risk of stroke in patients with atrial fibrillation
CI	Confidence interval
DDD	Defined daily dosage
DEG	Digital era governance
DRG	Diagnosis-related group system
ECG	Electrocardiogram
eGFR	Estimated glomerular filtration rate
GP	General practitioner
HATS	Health administration through structured records
ICD-10	International statistical classification of diseases
ICT	Information and communication technology
IPLOS	Norwegian national system for care statistics
IT	Information technology
NPM	New public management
NT-proBNP	N-terminal prohormone of brain natriuretic peptide
OR	Odds ratio
PCIS	Patient care information system
QI	Quality indicator
sEPR	Structured electronic patient record
WHOCC	WHO Collaborating Centre for Drug Statistics

(www.wikipedia.com):

"**Warfarin** (also known under the brand names Coumadin, Jantoven, Marevan, Lawarin, Waran, and Warfant) is an anticoagulant. It is most likely to be the drug popularly referred to as a "blood thinner," yet this is a misnomer, since it does not affect the thickness or viscosity of blood. Instead, it acts on the liver to decrease the quantity of a few key proteins in blood that allow blood to clot".

"**Atrial fibrillation (AF)** is the most common cardiac arrhythmia (irregular heart beat). It may cause no symptoms, but it is often associated with palpitations, fainting, chest pain, or congestive heart failure. AF increases the risk of stroke; the degree of stroke risk can be up to seven times that of the average population, depending on the presence of additional risk factors (such as high blood pressure). It may be identified clinically when taking a pulse, and the presence of AF can be confirmed with an electrocardiogram (**ECG**) which demonstrates the absence of P waves together with an irregular ventricular rate. In AF, the normal regular

electrical impulses generated by the sinoatrial node are overwhelmed by disorganized electrical impulses usually originating in the roots of the pulmonary veins, leading to irregular conduction of impulses to the ventricles which generate the heartbeat".

"**An antipsychotic (or neuroleptic)** is a tranquilizing psychiatric medication primarily used to manage psychosis (including delusions or hallucinations, as well as disordered thought), particularly in schizophrenia and bipolar disorder. A first generation of antipsychotics, known as typical antipsychotics, was discovered in the 1950s. Most of the drugs in the second generation, known as atypical antipsychotics, have been developed more recently. A number of harmful and undesired (adverse) effects have been observed, including lowered life expectancy". Neuroleptics are contraindicated to patients with Parkinsonism as they create Parkinson symptoms.

"**ACE inhibitors or angiotensin-converting enzyme inhibitors** are a group of drugs used primarily for the treatment of hypertension (high blood pressure) and congestive heart failure. Originally synthesized from compounds found in pit viper venom, they inhibit angiotensin-converting enzyme (a component of the blood pressure-regulating renin-angiotensin system), thereby decreasing the tension of blood vessels and blood volume, and in turn lowering blood pressure".

"**Angiotensin II receptor antagonists**, also known as angiotensin receptor blockers (**ARBs**), AT1-receptor antagonists, are a group of pharmaceuticals which modulate the renin-angiotensin-aldosterone system. Their main uses are in the treatment of hypertension (high blood pressure), diabetic nephropathy (kidney damage due to diabetes) and congestive heart failure".

"**The N-terminal prohormone of brain natriuretic peptide (NT-proBNP)** is a 76 amino acid N-terminal fragment of brain natriuretic peptide. Both BNP and NT-proBNP levels in the blood are used for screening, diagnosis of acute congestive heart failure (CHF) and may be useful to establish prognosis in heart failure, as both markers are typically higher in patients with worse outcome. The plasma concentrations of both BNP and NT-proBNP are also typically increased in patients with asymptomatic or symptomatic left ventricular dysfunction".

In medicine, **comorbidity** is either the presence of one or more disorders (or diseases) in addition to a primary disease or disorder, or the effect of such additional disorders or diseases.

"A **benzodiazepine** is a **psychoactive drug** whose core chemical structure is the fusion of a benzene ring and a diazepine ring. The first benzodiazepine, chlordiazepoxide (Librium), was discovered accidentally by Leo Sternbach in 1955, and made available in 1960 by Hoffmann–La Roche, which has also marketed diazepam (Valium) since 1963. Benzodiazepines enhance the effect of the neurotransmitter gamma-aminobutyric acid (GABA), which results in sedative, hypnotic (sleep-inducing), anxiolytic (anti-anxiety), anticonvulsant, muscle relaxant and amnesic action. These properties make benzodiazepines useful in treating anxiety, insomnia, agitation, seizures, muscle spasms, alcohol withdrawal and as a premedication for medical or dental procedures".

"**The Anatomical Therapeutic Chemical (ATC) Classification System** is used for the classification of drugs. It is controlled by the WHO Collaborating Centre for Drug Statistics Methodology (WHOCC), and was first published in 1976. The classification system divides drugs into different groups according to the organ or system on which they act and/or their therapeutic and chemical characteristics. Each bottom-level ATC code stands for a pharmaceutically used substance in a single indication (or use)".

Contents

Can a structured electronic medical record with decision-making support improve nursing home quality?

Introduction

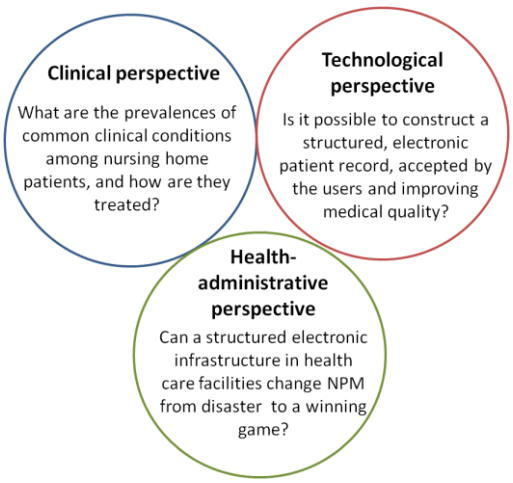
We have defined the prevalence of several medical conditions, mistreatments and procedures in nursing homes and then examined if an electronic medical record system with decision support improved quality.

This work can be viewed from multiple angles.

It may be regarded as a standard clinical work which seeks information about clinical conditions in a nursing home population. Little research has been accomplished attempting to determine what distinguish this population from other populations of elderly. Patients above 75 are often excluded from regular clinical trials. Even the simplest counts and surveys are therefore needed as a basis for future research.

Another perspective is the technological. Is it possible to construct a basic dataset and a structured electronic medical record system that covers all documentation needs in nursing homes? To what extent then, are doctors and nurses satisfied with the tool in their daily patient-related work? Would reminders, based on automatic procedures, be able to change treatment practice?

Then there is the administrative perspective. Is there a connection between modern electronic medical records and healthcare governance? Can a structured electronic infrastructure in healthcare improve the creation of valid quality and production parameters, and through this, impact motivation, production and quality in a positive way which was not possible by traditional New Public Management methods?



Background

Norway has 4.98 million inhabitants (January 2012), 55 public hospitals, 41,052 nursing home beds and 1,796 beds in old people's homes. 96.8% of nursing home beds are in single rooms and 43.3% of all deaths (41,342 in total) are in nursing institutions [1]. The healthcare system is split into first and second line services. The second line contains the 55 hospitals and specialist services (including private specialists). The second line is administered and financed directly by the state. First line services are administered and financed by the municipalities (N = 431). The first line covers general practice (GP) services, mother and child care, home-care and nursing homes (N = 900).

It is expected that nursing homes will play an important role in healthcare delivery in the years ahead. The population is growing older and patients admitted to hospitals are being discharged earlier. A Norwegian white paper states that reform is needed to the collaboration between primary care and hospitals [2]. The growth in costs and utilization of hospitals is not sustainable. Among several proposals, the white paper points to accomplishments involving early discharges from hospitals to nursing homes which offer structured rehabilitation programmes. Quality will thus be under pressure, expectations of services will rise and clinical complexity will grow. New strategies are needed to meet this situation. Modern clinical information systems with decision-making support may be part of that.

Bergen had 250,000 (2006) inhabitants and 32 (35, 2012) nursing homes (2,300 beds). The number of beds ranges from 20 to 189 per institution. As of January 2013, the municipality had a population of 267.900.

Quality improvement strategies in general

Documenting quality status and improving quality in nursing homes is a challenge. Internationally, several quality improvement studies have been undertaken: Nursing homes with a smaller number of beds, operating for profit and having a high level of nursing staff may improve quality [3]. It has been claimed that marginalization of physicians in the nursing home threatens the overall care of increasingly frail nursing home residents who have medically complex illnesses [4]. Medication quality improvement efforts in nursing homes should probably focus on the medications commonly implicated in errors and should continue to discourage or closely monitor the use of medications considered potentially inappropriate in the elderly [5]. A menu-driven incident-reporting system has the potential to enhance

quality improvement efforts in nursing homes [6]. In pain management a multifaceted collaborative intervention proved valuable, involving audit and feedback on pain management, education, training, coaching using rapid-cycle quality improvement techniques, and inter-nursing-home collaboration [7]. There has even been shown to be a relationship between ambitious targets and nursing home quality [8]. Implementing small, focused and inexpensive interventions, like monitoring blood pressure **(**BP) controls, can improve quality [9]. Structured drug audit has been tested in nursing homes in Bergen and it reduced drug related problems [10].

Simply providing comparative performance feedback may not be enough to improve resident outcomes [11]. Targeting specific drugs in the surveyor's interpretative guidelines as a method of reducing potentially inappropriate medication use does not produce the desired gains in terms of improving the quality of medication use either [12].

It is difficult to envisage adequate quality control without the use of modern technology like medical record systems with alarms, statistics and decision-making support in addition to already proven tools for improving the quality of drug use. The effectiveness of decision support tools has been shown in several studies and should be tested in nursing homes [13, 14].

Structured electronic medical records

Norwegian authorities have revealed weaknesses in the record systems at nursing homes during a number of inspections and these issues are addressed in several reports:

- "The Norwegian Board of Health Supervision takes very seriously what has been presented in terms of record systems and quality of records at the nursing homes. This applies both to the widespread lack of efficient record systems for all employees, the lack of systematic approach to what is being recorded, and a widespread lack of documentation for important and relevant information about patient medication" [15].
- "There seems to be a need for central authorities to invest heavily to develop an adequate electronic documentation system with comprehensive medical records that are user friendly for all healthcare professionals in nursing homes" [16].

The technical developments and medical studies performed during this project are thus in line with needs in the nursing and care sector and with public plans.

Structuring medical information may be a prerequisite to success when it comes to developing adequate and modern medical record systems [17, 18]. To our knowledge, however**,** few full-scale structured medical record systems have yet been developed in Europe, and scientific testing for improvements in the quality of full-scale medical record systems is still pending.

After the initial, innovative decade with electronic patient records, the international medical community began to concentrate on future gains from using electronic patient records [19], enhanced efficiency, less error, better cost control, and improved therapeutic regimes and organizations as a result of database analyses.

American authorities defined a number of particularly important factors at the time of an attempted healthcare reform in the USA in the early 1990s [20]. Central to this was the motto of "Getting the right information to the right person at the right time". In order to achieve this and other objectives, attention was to be directed towards a number of aspects in particular: use of standard forms and standardized data definitions, a nationwide electronic healthcare network, data capture from the day-to-day healthcare work, widespread use of electronic patient records and database analyses for continuous quality enhancements and patient involvement. Such objectives and methods are also key to Norwegian plans [21-25], but the gains envisioned have yet to materialize. Use of information technology (IT) in the health services has not yielded the professional gains and benefits expected. One important prerequisite for achieving such gains may be to structure the electronic record notes. Are there any research-based grounds for this?

In order to accommodate the growing complexity and pressures of modern medicine, we need tools for rational documentation and quality control [30]. Although there are many components in place to achieve such objectives, such as a secure healthcare network, reporting standards and widespread use of electronic patient records, it can be difficult to achieve the aims of effective quality assurance tools without targeted structuring of segments of the body of medical information. This structuring can be done by developing basic data sets for the most important clinical situations within each specialty. It is probably unrealistic to think that free-text search methods can be developed to such a level that necessary data can be obtained with satisfactory quality. Great expectations attach to the possibilities that open up for presenting medical knowledge on doctors' computer screens, either as freestanding reference works or as integrated control functions in an electronic record system. The reason

there have been problems with the implementation of such arrangements is a lack of structure in the basic information to which such systems need to respond.

The opposite of structured (or semi-structured) patient records is free-text records. In a free-text system “blood pressure” will be recorded as written; "BP: 120/80" or as "blood pressure 120:80" or in any one of about 30 other ways of recording blood pressure in free-text.

Most record systems on the market do not have the option of recording medical data in a standardized, structured fashion. In structured systems, recording is done in predefined fields: “BP_syst” and “BP_diast”, and the new values are always added to the same data register. The structured way of recording parameters opens up the possibility of making graphs, alarms (e.g. “if blood pressure is below a defined value, then pop up an alarm”) and population filters (e.g. “if patient blood pressure is above a certain value, then put on a list together with similar patients”). **Figure 1** demonstrates a structured form.

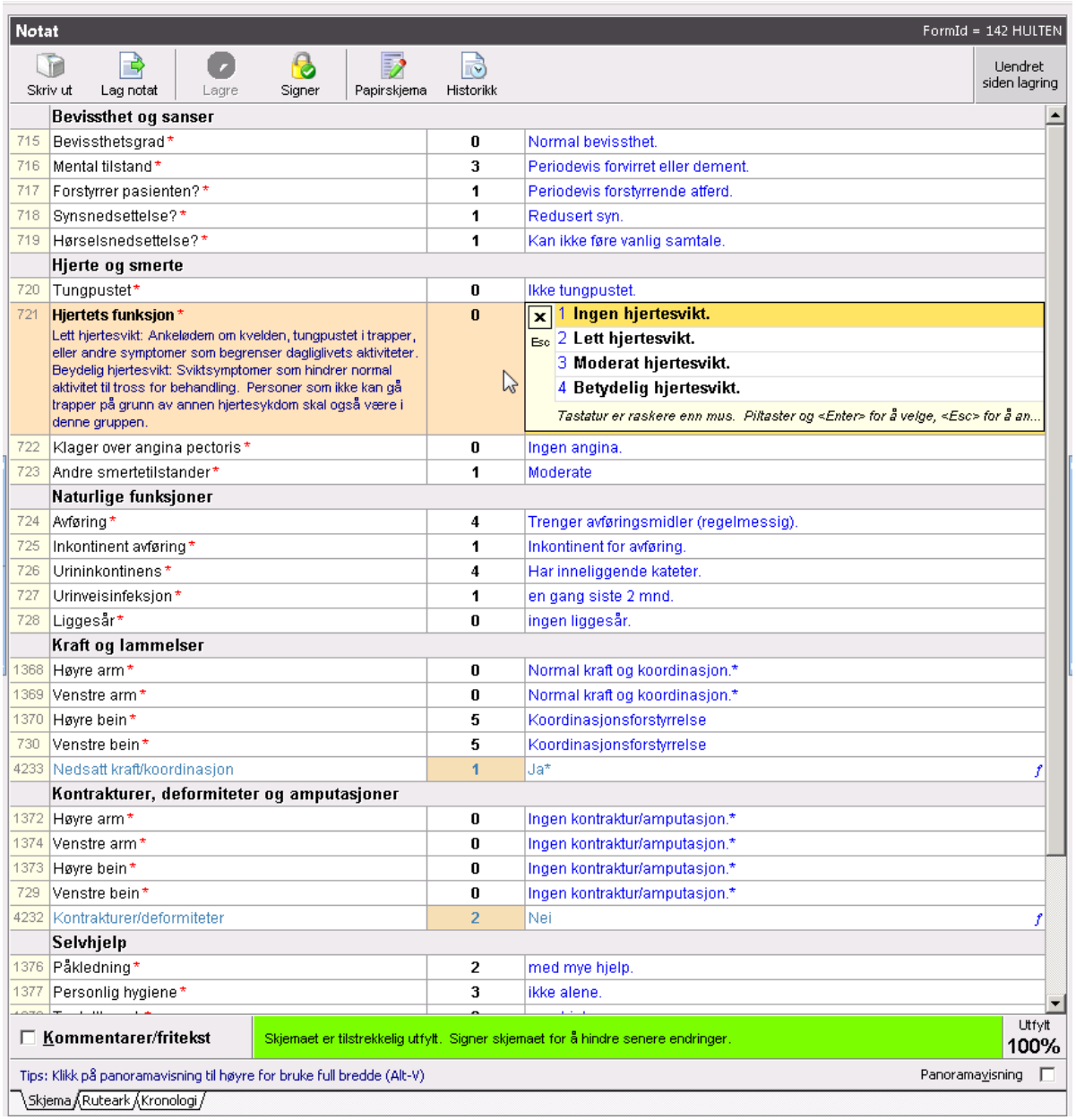


Figure 1. Demonstrates a "nursing load form" of the structured medical record system. Instead of free-text the different parameters are predefined. It is important for the practical daily work that the forms can be presented in different ways; as forms (above), as worksheets (convenient for test) and as concatenated text (as part of the total chronological record). This switch among different ways to present content is done by clicking the tabs at the bottom of the form. By hocking the field "Kommentarer/fritekst" a field for adding free-text opens.

Figure 2 below **and figure 2, publication 4** demonstrate how alarms are presented to the user from within the patient record, and **figure 3** below **and figure 1, publication 4** demonstrate practical use of population filters/lists.

Figure 2. Demonstrates how alarms are presented. Different categories of alarms exist; interactions (DRUID interaction database is part of the system and scans all medication lists continuously), conflicts with the administrative procedures (e.g. "not weighed last 30 days"), more complicated clinical alarms (e.g. "the patient is using several antihypertensives but systolic blood pressure is below 110"), planned time stamps (e.g. "it is time for a new B-12 injection") or logical inconsistency between drug list and the list of diagnoses (e.g. "the patient is using insulin but does not have the diagnosis diabetes, would you like to add?").

Details of population filters

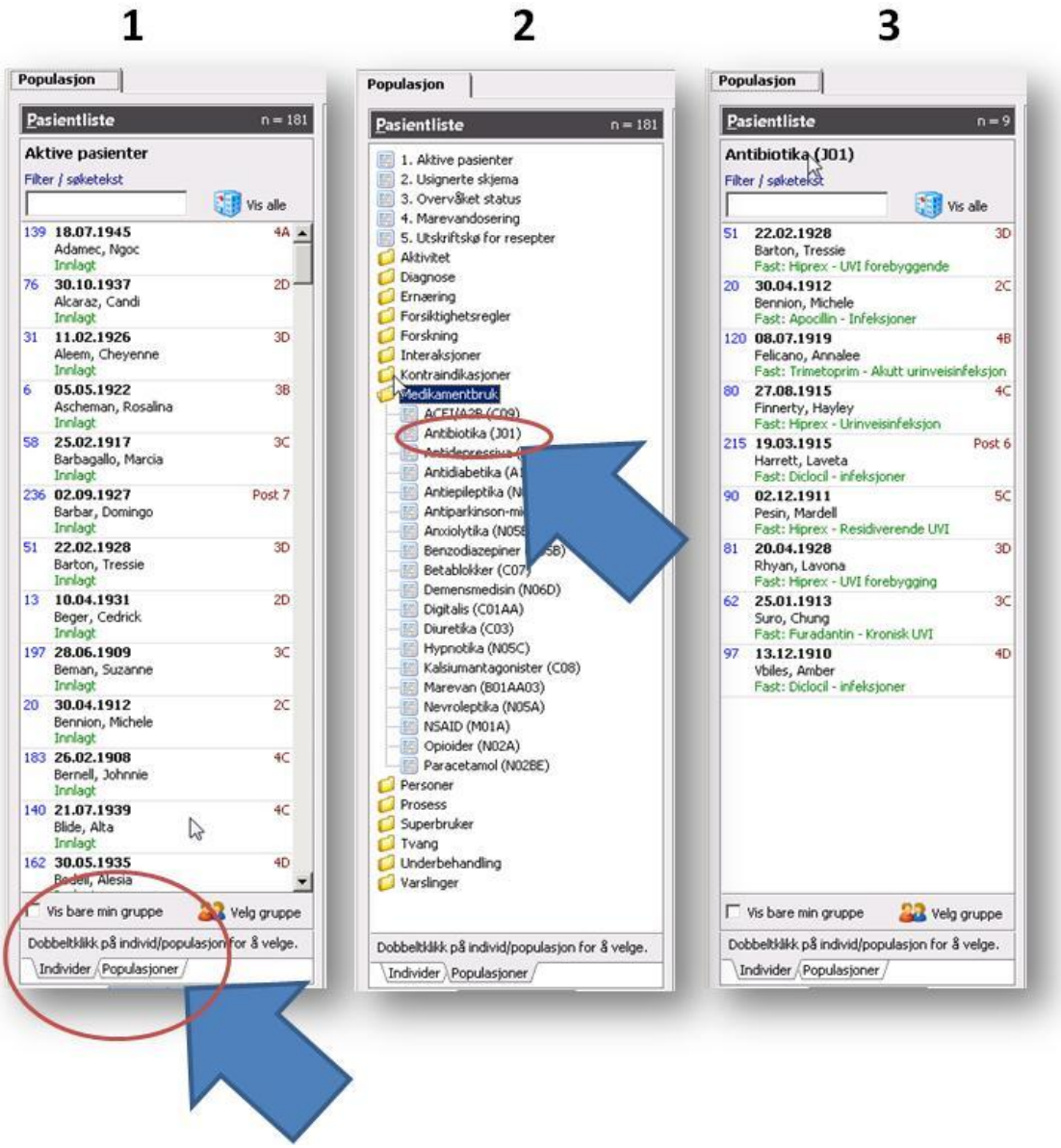


Figure 3. Demonstrates the practical use of population filters. If you need to know which patients are on antibiotics at the moment you; step 1 – click on the population tab of the patient list (all patients in this institution), step 2 – choose one of the predefined medication filters ("antibiotics") and step 3 – the list of patients on antibiotics is presented. Several patient filters within different categories are available, also filters based on complex criteria (e.g. "patients with a diagnosis of atrial fibrillation without any antihrombotic medication").

Structured record and basic clinical data set

Recording data by means of structured form is faster, and the content satisfies the needs of a normal medical record [26]. In a Swedish study of 300 general practitioners (GPs), it was found that even in a busy general practice the doctors found the workload imposed by structured recording acceptable. In a large-scale EU project an electronic system (KNAVE-II) was used to fill in sometimes complex, structured forms, and completion was done as part of the everyday clinical routine. Use of time and user satisfaction was better with electronic, structured data capture/record-keeping than with manual systems [27]. On the face of it, it may seem sensible to mix structured data in the record with the option of free-text recording in order to increase flexibility for the users [28]. Aabakken and colleagues at Ullevål University Hospital discovered this when setting up and evaluating the SADE, a database for gastroenterological patients [31, 32]. Research has also shown that details in the design and layout of electronic forms can affect how rationally they are used [33, 34]. However, a study has shown that free-text comments from the doctors in connection with electronic drug prescription alter the opinion content of the structured prescription [29].

In the case of the electronic free-text record we know that the quality of the data in the databases is not good enough for research purposes [30, 31]. The same applies to decision support systems. In a geriatric hospital ward a group of researchers studied differences in data quality between two patient groups [32]. In one group, the structured record was used, while in the other group the traditional record was used. The authors concluded that the data quality was considerably better in the group with the structured record and that the improvements seemed to be linked to the structured data capture, not to the focused approach that is natural when introducing new systems.

For nurses it has been shown that documentation quality and scope for targeted intervention improved on introducing electronic systems with structured nursing documentation [33].

A number of studies have evaluated electronic forms filled in by patients, especially for logging symptoms. In back patients, pain recording with the aid of a small laptop was compared with the use of manual questionnaires and phone interviews [34]. Electronic recording was entirely valid, and patients preferred this method. By the same token, a similar pain form was studied among 60 children aged 8–16 with headaches or juvenile rheumatoid arthritis [35]. Both data quality and compliance were better in the group using electronic forms.

At two urology wards in the USA, nine structured, standardized forms were developed, replacing all other medical documentation for both in- and outpatients over a period of time [36]. The authors of the study concluded that it is possible to agree on such a basic data set among urologists and that the work can form the basis for nationwide use of electronic, clinical structured records.

Decision support

Decision support is closely correlated with structured record information, because the decision support tools have to respond to information in the record – pathological test results, for example. This is easier to accomplish if the underlying data are structured. A number of major European projects hinge on this issue [37]. There are weaknesses involved in introducing consensus-based therapeutic regimes in a population. Often test results are not followed up. In a study of an electronic reminder system, the follow-up proportion in the intervention and control groups was 46% and 22%, respectively. The intervention consisted of an on-screen electronic reminder at the time of ordering the tests or samples [19].

In early Norwegian studies it was difficult to prove the effect of such electronic initiatives [38, 39]. Part of the explanation may be that patients with the clinical conditions studied (hypertension and diabetes) are traditionally given a great degree of ongoing information via the pharmaceutical industry and there is thus reduced potential for improvement. Later studies have shown positive effects within several fields of therapy.

The health care organization Kaiser Permanente in Ohio has introduced a comprehensive electronic patient record system that supports quality interventions and a number of administrative tasks [40]. Cost-benefit analyses have shown that the organization can save expenditure that justifies the costs of maintaining the system. Feedback on personal prescription practice among GPs is a promising model for general improvement [31]. Improvements have also been reported when GPs using the electronic patient record receive feedback on the treatment of cardiac and stroke patients [13].

In a meta-analysis Kawamoto and colleagues deal with studies on the effectiveness of decision support systems [14]. Literature searches were done in Medline, CINAHL and Cochrane, choosing studies that showed significant improvement in clinical practice and studies that dealt with 15 commonly discussed aspects of such systems. Combined, this gave 70 different studies. 68% of them showed significant improvement in practice. Multiple logistical regression analyses identified four independent factors that increased the probability

of a positive result: automatic presentation of decision support information integrated into the work process, recommendations rather than directives, advice at the moment the decisions are taken and computer-based support.

Of the 32 systems that met all the criteria for improving practice, 30 brought about some improvement in clinical practice. On an experimental basis a positive effect was found from periodic feedback, from sharing recommendations with the patients and from demanding documentation from anyone not following the recommendations.

Population-targeted intervention

The traditional medical approach focuses on the individual, with particular emphasis on symptoms, signs and test results emerging from the encounter with individual patients. In order to ensure accessible and correct treatment for all patients, it is also possible to operate using population-directed control measures.

At healthcare institutions using electronic patient systems, a database is automatically created in which all patient contacts are registered. These databases can contain easy-to-access epidemiological data and can represent one option for population-targeted control systems. For example, it is possible to find all patients who have received special treatment within a given period. Such databases from multiple institutions can be merged to form the basis for important evaluations in relation to large, clinical populations [13].

Use of standardized, electronic registration on a large scale can have major consequences for therapeutic regimes. This has been shown for example in a large study among American ophthalmologists [41]. Eight public eye wards with a total of 160 ophthalmologists took part in recording individual clinical data on all patients undergoing cataract surgery. The purpose was to evaluate the consequences of systematic, structured electronic recording. Evaluating the data collected turned out to have an effect on the overall therapeutic regime for the patients. The authors concluded that this form of data registration has potential as a continuing method of evaluation and should be available nationwide in future.

The Veterans Health Administration is the largest single supplier of healthcare services for HIV-positive people in the USA. Structured patient data have been stored for a number of years now, and it has been shown that analyses of the central database affect the therapeutic regimes. The central database is currently administered by a national quality assurance organization [42].

The benefit of population-targeted intervention has also been proved in several studies. In a study with 3,073 patients with hemofec test appointments, the compliance rate was just 18%, but increased to 33% with the introduction of a system for sending patients reminder letters automatically. The patients were found by searching the database [43].

Doctors' and nurses' views

The users' views on data systems are important for the real-term prospects of spreading such tools. In a study on doctors' views on introducing an electronic record system and a reporting system in a large insurance organization in the USA, almost all the doctors thought that the electronic patient record brought about improvements in the working situation and patient treatment, while some three-quarters saw advantages to the system for reporting results [44]. Improvements in coordination of therapeutic measures, opportunities to pinpoint cases of mismedication and possibilities for responding to pathological test results with sufficient speed were highlighted in particular.

GPs' views on their own ability to follow up pathological test results and on any auxiliary systems have been examined in an American study with 216 doctors with electronic patient records [45]. Of those who replied (65%), less than one third were happy with the current systems' ability to retain an overview of pathological test results, including X-ray results. 90% wished for automated systems to keep tabs on the pathological test and investigation results. 97% believed they could do a better job if they received help from electronic reminders.

Nurses' views on electronic patient records have been studied at a major hospital in Florida [46]. Of 100 nurses, one third felt that electronic patient records resulted in a reduced workload, and roughly the same proportion preferred being able to provide documentation at the patient's bedside but said that this was often made difficult. A quarter thought that documentation was improved and the use of electronic patient records would improve patient safety. Nurses with experience of information technology consistently had more positive views than those without such experience.

Some clinical issues in nursing homes

Use of psychoactive drugs and differences between institutions

There are several good reasons to monitor the use of psychoactive medications in nursing homes. The high consumption of psychopharmaceuticals in nursing homes has been emphasized in a number of studies and the prevalence of psychoactive drugs has been well documented earlier, but some years ago [47-49]. Few authors have placed the emphasis on treatment differences between nursing homes and the general differences in medication of patients suffering dementia as opposed to non-demented nursing home patients [50-65].

Atrial fibrillation and heart failure

Two of the most frequent diagnoses among the elderly are atrial fibrillation (AF) and congestive heart failure. The prevalence of AF has not been studied in Norwegian nursing homes, nor has the way AF is treated. The question of under-treatment of heart failure in nursing homes has been raised earlier [48].

AF is an independent risk factor for developing a stroke [66], and in the elderly it is one of the most important causes of stroke [67]. It is important that patients with multiple risk factors for embolisms are adequately anticoagulated [68]. The current guidelines state that most patients over the age of 75 with atrial fibrillation should be anticoagulated, but increasing age often produces the opposite effect [69, 70].

It is important to consider stroke risk against bleeding risk when deciding whether or not to treat. The relationship between the two factors may be different for the oldest population than for younger patients. Stroke risk in AF patients can be estimated using the CHADS2 score [71, 72].

To estimate the risk of bleeding for AF patients on warfarin treatment, bleeding risk scores can be used [73]. In the study cited the high-risk bleeding individuals (5.6% bleeding risk) had a 7% stroke risk.

When it comes to methods for diagnosing heart failure, clinicians often wonder to what extent proBNP is biased by age, renal failure and weight.

Weight loss

The presence of nutritional failure in Norwegian nursing homes has been questioned [74]. Little research in the field has been done so far. There is good evidence showing that

inappropriate weight loss in the elderly materially impairs their quality of life and life prospects. The convalescence period for illness also increases substantially [75]. A significantly increased risk has been shown for secondary complications like pressure sores [76], infection, depression and functional impairment [77, 78] as well as increased mortality [79-83]. The necessity of good weighing routines is therefore obvious.

Hospitalizations from nursing homes

Little research has been done on admissions from nursing home to hospital. There are no studies in this field from Norway [84]. Internationally, a correlation has been found between the lack of documented decisions on the level of treatment and the increase in admission rate [85]. Clear documentation in logs and records concerning hospital admissions and heart-lung do-not-resuscitate decisions can prevent unnecessary admissions. Acknowledged routines currently in place to treat terminal patients (Liverpool Care Pathway) may be important to make these decisions easier in nursing homes [86]. We also know that information gaps commonly occur when elderly patients are transferred from a nursing home or seniors' residence to the hospital [87].

#

Based on this knowledge we developed a full-scale, interdisciplinary, semi-structured (free-text AND structured forms) electronic medical record system during the period 2005-2008 together with the basis dataset (the collection of semi-structured forms) covering documentation needs in nursing homes. A collection of electronic alarms (e.g. "the patient has not been weighed for the last 30 days") was also developed together with a collection of population filters (e.g. "patients on this list are using neuroleptics"). We planned to test scientifically whether decision-making support would bring about quality improvements in some clinical (e.g. "percentage patients on neuroleptics") and practical (e.g. "percentage of patients not weighed for last 30 days") parameters in a before-after study where the intervention was full-scale use of the sEPR system in nursing homes.

After four months' training the nursing homes switched to the new system and used it as the only medical record system on a daily basis for the next 12 months (February 2008 – February 2009).

Objectives

Primary objectives

- To define clinical and practical parameters which need to be improved, and which can be used as endpoints in an intervention study, among long term patients in nursing homes.
- To test if a structured electronic medical record system with decision support improves quality of the endpoints.

Secondary objectives

- Investigate the incidence of hospitalizations from nursing homes, the major diagnostic reasons, what burden these hospitalizations represent for the main hospital departments, and what impact manpower and short to long-term bed ratio has.
- To pinpoint any differences in treatment with psychoactive drugs between participating nursing homes, investigate which drugs are currently prescribed most frequently for long-term patients in nursing homes, estimate prevalence of administration for the following drug groups: neuroleptics, antidepressants, antidementia agents, opioids and the neuroleptics/anti-Parkinson's drug combination, and study comorbidity correlations. We also wanted to study differences in the administration of medication for patients with reduced cognitive functions in relation to patients with normal cognition.
- To investigate to which degree long-term nursing home residents with AF received antithrombotic treatment and to what extent patients with NT-proBNP above 225 pmol/l were treated with angiotensin-converting enzyme (ACE) inhibitors/A2 blockers, beta-blockers, statins and diuretics, and to discuss ProBNP as a diagnostic tool. We also wanted to study whether there were differences in treatment between the nursing homes and to investigate how often long term patients in nursing homes in Bergen are being weighed.
- To try to find a theoretical link between structured medical records and NPM (New Public Management) and thereby connect it to healthcare governance in general.

Materials and Methods

Material and methods of the hospitalization study

Publication 1.

During the period March 2006 to March 2007 (12 months) all hospital inpatient admissions from nursing homes in the Municipality of Bergen to the primary and referral hospital were recorded (the two only hospitals in Bergen). This was done by searching the ambulance service's register of transports from nursing home addresses to the two hospitals. These patient transports were then compared with the hospitals' case history registers to find ward and diagnoses (ICD-10) and length of stay. The ambulance register was the only complete source to find fairly complete figures on hospitalizations from nursing homes for this retrospect study. To search more information about each patient from the hospital records was beyond the scope of the study. Calculations are based on the principal diagnosis. Information about physician manpower, number of total beds and number of short-term beds was gathered from the county health administration.

Two hospitals are delivering hospital services to the city and surrounding municipalities. Bergen population represents 62.5% of the total population served by the hospitals (population 400 000).

There is only one, public, ambulance service in Bergen. Close to 100 percent of admissions from nursing homes to the hospitals are done by means of ambulance. By all transports, patient name, transport addresses and key medical observations are registered in a database.

Linear regression analysis was used to relate admission rates for the nursing homes to the proportion of short-term beds, and the proportion of explained variation in admission rates expressed by the determination coefficient (R^2). For analyzing data we used Excel and JMP8.

Material and methods of the prevalence studies

Publication 2 and 3.

Bergen has approximately 250,000 inhabitants and 32 nursing homes (2,300 beds), **figure 1, publication 1**. Bed numbers range from 20 to 189. Seven nursing homes participated in this study. Participating nursing homes were selected based on a relative similarity of functions,

county ownership (no private institutions) and physician staffing. Further nursing home characteristics are presented in **table 1, publication 2**.

Information about the patients was gathered during the period March-April 2008. Twenty-four medical students conducted the data collection, which consisted of copying medication cards (information about drug names, if regular or as-needed, prescription and dosage), weighing by means of local tool, but standardized clothing, finding previously recorded weight/date, details of any stroke suffered and degree of cognitive impairment. Electrocardiography (ECG) was conducted to diagnose atrial fibrillation and a standardized set of blood samples was analyzed (haemoglobin, B-type natriuretic peptide (ProBNP), sodium, potassium, calcium, albumin, creatinine, blood urea nitrogen, urate, estimated glomerular filtration rate (eGFR)).

Only long-term patients (N = 513) were included. 447 of the patients were blood-tested and 484 ECG'ed. 488 of the patients were weighed and it was possible to find the recorded weight in 431 patients. It was possible to conclude if the patient had undergone a stroke in 462 of the patients and if they were demented or not in 511. Complete medication records existed for all patients.

We used ProBNP > 225 pmol/l as an indicator for patients with probable heart failure. To get an impression of the biasing effect of age, weight and renal function in this population, we performed bivariate fits of ProBNP by these factors and a multiple linear regression analysis of the square root of proBNP on age, weight and the square root of eGFR. We also estimated non-parametric correlation (Spearman's) between ProBNP and eGFR. Linear regression analysis was used to examine the dependency of proBNP on age (in years), weight (in kg) and renal function (eGFR), and explained variation was quantified by the determination coefficient (R^2). A multiple linear regression analysis of the square root of proBNP on age, weight and the square root of eGFR was performed to get a prediction equation for ProBNP.

In order to group the material into patients with/without cognitive impairment, we used the Berger scale [88] and recorded patient information. A caregiver who knew the patient decided between 6 "level descriptions" of cognitive impairment, thus rating the degree of severity as a score from 0 to 6. The method was validated by comparing the extent to which drugs for dementia were given to patients scoring above 0, giving a 95% overlap.

The recorded data were keyed into Excel and the drugs coded according to the Anatomical Therapeutic Chemical (ATC) Drug Register [89]. For each drug the students punched in the full ATC code, dosage, number of times per day given, total daily dosage and whether regular/as-needed. For the psychoactive drugs which are part of the comparison between institutions, Defined Daily Dosages (DDDs) were registered (except for opioids being part of kodine/paracetamol combination drugs). To compare the total use of psychoactive drugs (hypnotics, anxiolytics, anti-dementia drugs, neuroleptics and opioids) between institutions, we used the calculated parameter; [(Drug DDD) x (% of patients in institution on drugs of drug-class)].

Straight counts were performed in Excel, but for statistical analyses JMP version 8 (from SAS), was generally used. Means and standard deviations (SD) are reported. To analyze differences in the average between multiple groups for continuous data, the Tukey-Kramer (Honestly Significant Difference) multiple comparison procedure was used as a parametric method (Clyde & Kramer, 1956; Ramsey, Ramsey & Barrera, 2010) and the Kruskal-Wallis analysis of variance as a non-parametric method. For analyzing ordinal and nominal data, the Pearson chi-square test was used and the results reported as odds ratios (OR) with 95% confidence intervals (CIs). All tests were done at significance level 0.05. To search for factors with potential impact on prescription rates we conducted a multinomial logistic regression analysis, and to adjust for differences in patient and nursing home characteristics we performed a two-way analysis of variance (ANOVA).

Material and methods of the sales statistics analysis

In addition we also analysed the sales statistics for 2011. An Excel file from the vendor contained all orders per institution (private and public), with drug names, amounts, ATC-codes and defined daily dosages. We performed this analysis to see if results from the prevalence studies, which showed considerable prescription differences between institutions, could be confirmed by using a different method to shed light on the question. All drug orders for the year 2011 from all nursing homes in Bergen (N 35) were analyzed. For all institutions the total yearly order was the sum of multiple (36-102) part orders, which indicates by need ordering, which again indicates that storing is probably not a considerable biasing factor.

Material and methods of the intervention study

Publication 4.

Based on information from the prevalence studies described above we decided to test the following endpoints; 1) the proportion of long-term patients with atrial fibrillation that were being given warfarin, 2) the proportion of long-term patients taking neuroleptics and 3) the proportion of long-term patients not weighed for the last 30 days. To perform this, a before-after intervention study was done. The before-after study was conducted as a double cross-sectional design. Instead of randomization, we decided to use the proportion of patients on digitalis, thyroxin and antidiabetics as internal controls (participants exposed to the same study, but these drugs were not part of any concrete intervention and were unlikely to undergo any changes by external factors) [90]. The proportion of patients on neuroleptics was in addition followed as a time-series (a sequence of data points, measured typically at successive times spaced at uniform time intervals) [91-93] in two nursing homes from 23 October 2008 to 15 July 2010.

Before-data

We used data from the prevalence studies described above as "before-data" in the intervention study.

Intervention

After defining endpoints through the before-survey we installed an electronic, structured patient record system which included decision support. The system had been developed and operating at Løvåsen educational nursing home (developing institution) for several years, funded by the Norwegian Medical Association and the Norwegian Research Council. Installation and training were carried out in the last quarter of 2008, and 6 of the 7 nursing homes were running the system on a daily basis from January 2009 for 12 months. After the active intervention period the number of nursing homes running the system was reduced to three institutions, owing to contracts between Bergen Municipality and another vendor having been signed before the project started. Løvåsen Nursing Home and two of the study institutions continued, and were the only institutions available for follow-up data. Data had to be collected directly from the electronic patient record system.

The technical intervention consisted of population filters and reminders. The system incorporated filters and alarms within several areas but we decided to test 4 filters and 2

reminders. Population filters were predefined filters that produced lists of patients according to criteria in seconds. The tested population filters were: a) "patients taking neuroleptics" (list and proportion), b) "patients taking warfarin" (list and proportion), c) "patients with the diagnosis atrial fibrillation and their treatment status" (list and proportion) and d) "patients not weighed for last 30 days" (list and proportion). Tested reminders visible in each patient's record, if the criteria were met, were: a) "patient has diagnosis of atrial fibrillation but is not on warfarin", b) "patient not weighed for last 30 days". **Figures 1-3** in this summary **and figures 1 and 2, publication 4** demonstrate how this was arranged within the application.

Results from the before-study were presented to the participating doctors during the first 12 months of intervention through three two-hour lectures.

After-data

Two institutions (E and F in **table 1, publication 2**) participated in the after-study. To collect the data we used the population filters in the medical record system to find the proportions of patients on endpoint drugs, internal controls and patients not weighed for the last 30 days. Before-data were extracted from the prevalence study for institutions E and F (N = 183) for the before-after analysis. Institution E participated with an additional department (22 patients) in the intervention study (N = 205, after).

To study user satisfaction we performed an anonymous survey among the doctors, nurses, assistant nurses and physiotherapists (N = 504). Potential respondents were all users defined in the electronic system. They were invited by e-mail to respond to an electronic questionnaire. 16 questions about position and several aspects of their view on the functionality of the application were presented. Questions were closed, with a score from 1-5 (worse – better). The survey was constructed by a group of study nurses from the institutions, with technical organization by the vendor.

Results

Table 1. Summary of published results

Main topic	Major results
Primary objectives	
The intervention study	The proportion of patients taking neuroleptics was reduced from 33.0% to 21.5% i.e. a difference of 11.5% (95% CI: 2.3 to 20.6%). Warfarin increased from 3.0% to 9.8% (p = 0.013), i.e. a difference of 6.8% (95% CI: 1.6 to 12.1%).
	The proportion of patients not weighed for the last 30 days was reduced from 72.6% to 16.0% (p < 0.001), i.e. a difference of 56.6% (95% (CI: 47.5 to 64.5%).
	The user survey showed high user satisfaction.
Secondary objectives	
Hospitalizations from nursing homes	Of all admissions 61.0% was to medical wards (ex pulmonary ward), 29.4% to surgical wards, 4.4% to the pulmonary ward, 3.0% to the neurological ward and 2.2% to other wards.
	For the medical and surgical wards, infections, fractures, gastrointestinal and cardiac diagnoses stood out as the most frequent reasons for admissions.
	The average length of stay was 4.3 days. There was no significant difference between the average length of stay on medical and surgical wards. 38.0% of the admissions had duration of only one inpatient day.
	Of all the admissions from all nursing homes in Bergen during 12 months (N 1,311), infection diagnoses represented 25.0%. Pneumonias and suspected pneumonias represented 51.0% of infections and 12.8% of all admissions. The incidence of hospitalizations caused by infection was 138/1,000 nursing home beds per year.
	Fractures were the second most frequent cause counting 10.2% of admissions. Hip fractures represented 71.7% of fractures and were the commonest.
	Fracture incidence varied between nursing homes from 0 to 16/100 patient years, the average being 6.4. The incidence of fractures treated in hospital among the total population was 5.6/100 patient years during the 12 months under review.
	Admissions from nursing homes to the medical wards made up 6.1% of the total number of admissions. For surgical wards the admissions counted for 3.8%. 100 nursing home beds create about 150 bed days in medical wards and 72 in surgical wards.
	Linear regression analysis showed a significantly higher admission rate for nursing homes with a high proportion of short-term beds than with a low proportion.
The study on psychoactive drugs	The average number of total number of regular drugs was 6.1 per patient. Classified according to principal ATC groups, the three most frequent were drugs for; ”nervous system”, ”digestive organs and metabolism” and ”heart and circulation”.
	The average number of as-needed drugs per patient was 3.8.
	24.4% were regularly given one or several neuroleptics, 9.7% of the patients had neuroleptics by way of an as-needed prescription. 6.4% of the patients on regular neuroleptics were using two different ones regularly. Risperidone was the most frequent regular given antipsychotic drug, haloperidol the most frequent as-needed neuroleptic.
	14.6% of the patients were on opioids (N02A) by way of regular medication and 28.7% by way of an as-needed drug. 41.5% of the patients received antidepressants as regular medication.

	Prevalence's of long-term patients in nursing homes being prescribed psychoactive medication were as follows: neuroleptics regular 244/1,000 and as-needed 98/1,000, antidepressants regular 419/1,000, anxiolytics regular 220/1,000 and as-needed 415/1,000, opioids regular 146/1,000 and as-needed 287/1,000.
	There were significant differences between nursing homes as a percentage of patients on drugs within the actual ATC main group. Differences were highly significant statistically for morphine, neuroleptics and antidepressants.
	Some patients being given drugs for Parkinsonism were also on neuroleptics, and prevalence of current medication was 2/1,000 among all long-term nursing home patients.
	Patients with impaired cognitive function were prescribed significantly fewer regular drugs than patients without impairment. The average for patients without impairment was 7.1 drugs and for the patients with impaired cognitive functions 5.7 drugs. There was no difference in the number of as-needed drugs for the two patient groups.
	In general there was a tendency to lower the prescription rate of all cardiovascular drugs for the patients with reduced cognitive functions, significantly for ACEI/A2B and diuretics. Neuroleptics were more frequently prescribed to patients with reduced cognitive functions. ProBNP (brain natriuretic peptide) was significant higher in the patient group without cognitive impairment. No such differences existed for atrial fibrillation or renal function.
	With regard to comorbidity we did not find any associations with the use of neuroleptics and stroke suffered or associations between neuroleptics and patient weight or weight loss/30 days.
	Use of antidepressants was positively associated with patient weight. No associations for benzodiazepines or hypnotics were found with stroke, weight or weight loss.
The atrial fibrillation and heart failure related results	18.8% of the patients had atrial fibrillation (AF). There was no significant difference in the occurrence of AF between the nursing homes.
	14.3% of AF patients were anticoagulated with warfarin.
	Significant differences in treatment for AF with warfarin existed between the nursing homes (from 0 to 50%).
	55.8% of patients who had suffered a stroke received some kind of antithrombotic treatment (ATC = B01A). 8.3% of these patients were given warfarin. 24.3% of patients with both stroke and AF were given warfarin while 73.0% were given warfarin or some other antithrombotic treatment.
	Patients with AF receiving no warfarin had suffered stroke significantly more often than those without AF . A patient with AF had 2.75 times higher odds of having suffered a stroke than patients without AF.
	13.2% of all patients had ProBNP > 225 pmol/l.
	Of cardiovascular related drugs, only diuretics and heart glycosides were used significantly more in the group with ProBNP > 225 pmol/l.
	Of the 36 patients with ProBNP > 225 pmol/l and adequate renal function (eGFR > 50 ml/min.), 8 (22.0%) were given ACE/A2B.
	A multiple linear regression analysis gave the following prediction equation between age, weight and renal function: $$ProBNP = (17.65 + 0.063 \cdot age - 0.07 \cdot weight - 1.17 \cdot \sqrt{eGFR}\,)^2$$ For example for an 80-year-old patient weighing 70 kg and having eGFR = 30 the predicted ProBNP is 129.39 pmol/l.

Results from sales statistics analysis

Previously unpublished data.

The monetary drug expense is not published due to business secret reasons. Institution differences are however illustrated by total DDD per bed per institution in **figure 4**.

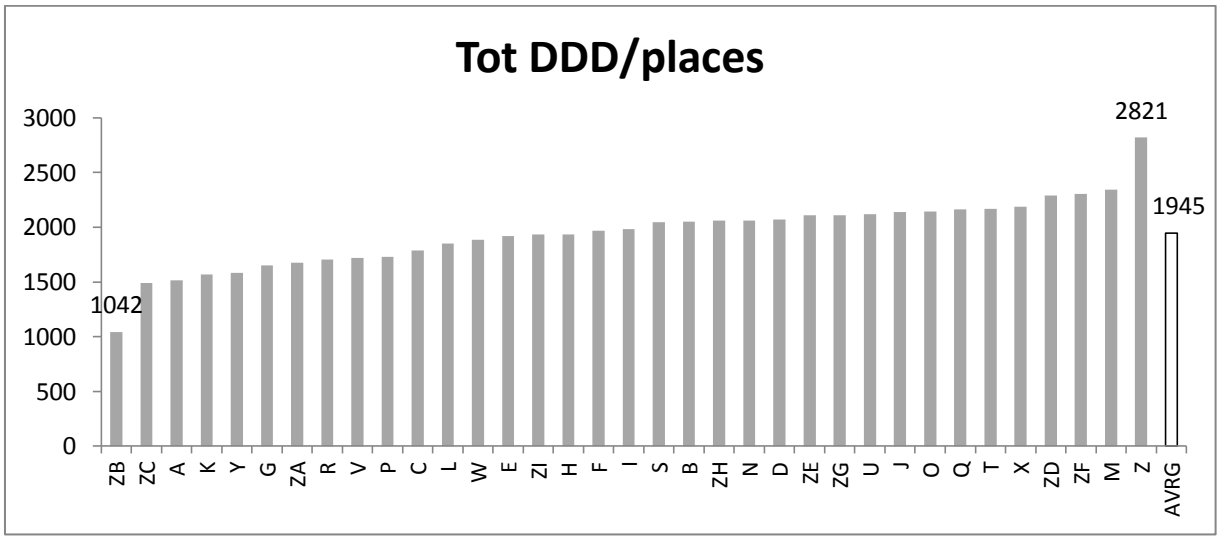


Figure 4. Differences of total drug DDD per bed between nursing homes (N = 35, min 1042, max 2821, SD 315,9) in 2011 in Bergen, Norway. Rightmost column shows average total DDD.

Several analyses were performed to shed light on the use of drugs per institution and possible impact factors. We did not find any correlations between “total DDD per bed” and “total number of beds”, “short-term factor” or if the institutions were public or private, as demonstrated in figures below.

Total DDD/places by total beds

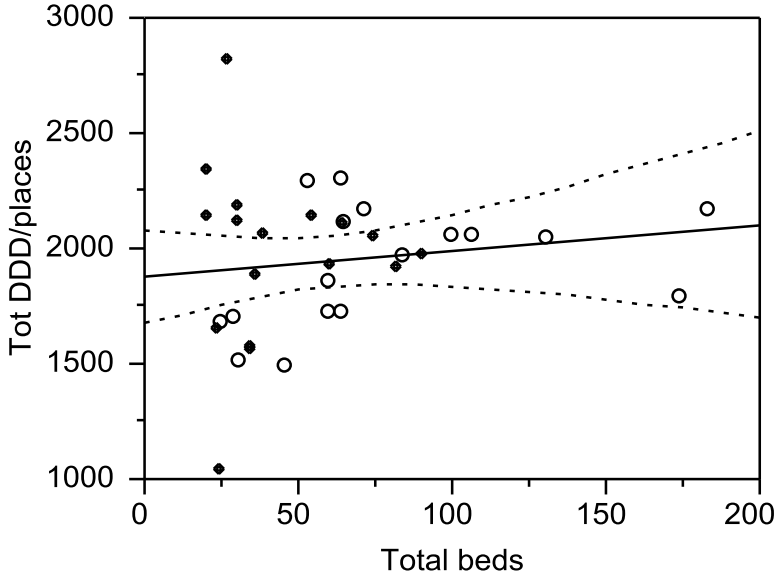


Figure 5. Association between (total yearly orders of drugs per nursing home (DDD))/beds and total number of beds among 35 Norwegian institutions (p = 0.4078). Square marks = institutions without short-term beds, round marks = institutions with short-term beds.

Total DDD/places by short-term beds/total beds

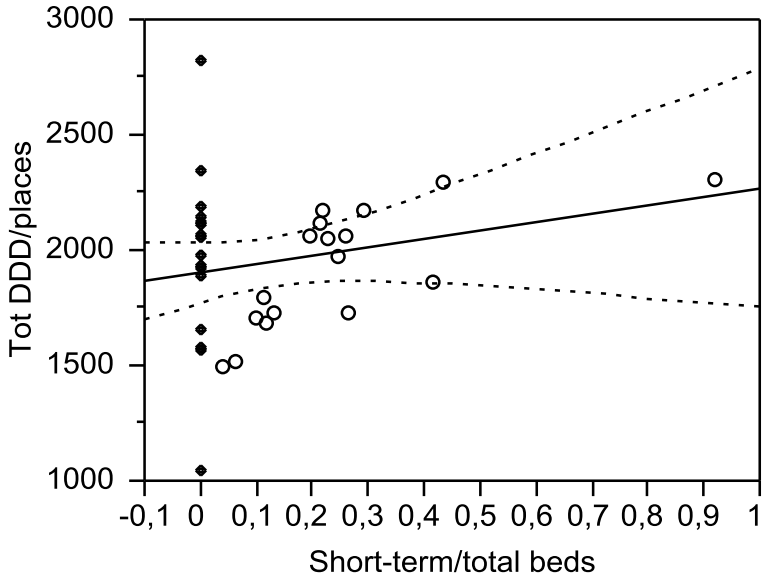


Figure 6. Association between(total yearly orders of drugs per nursing home (DDD))/beds and short-term bed factor among 35 Norwegian institutions (p = 0.1987). Square marks = institutions without short-term beds, round marks = institutions with short-term beds.

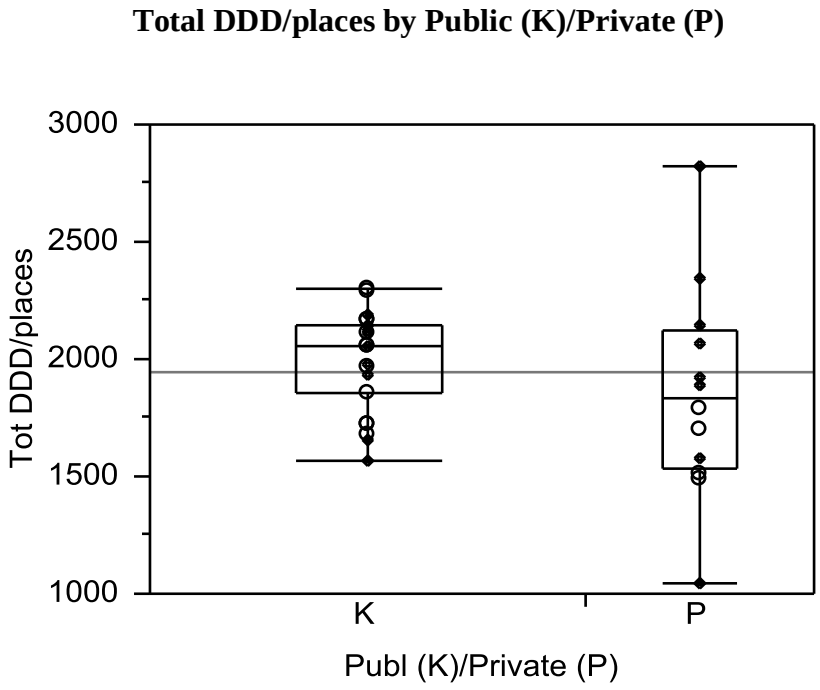


Figure 7. Association between (total yearly orders of drugs per nursing home (DDD))/beds for private (P) and public (K) nursing homes in Bergen Norvay. (Wilcoxon, p = 0.1753).

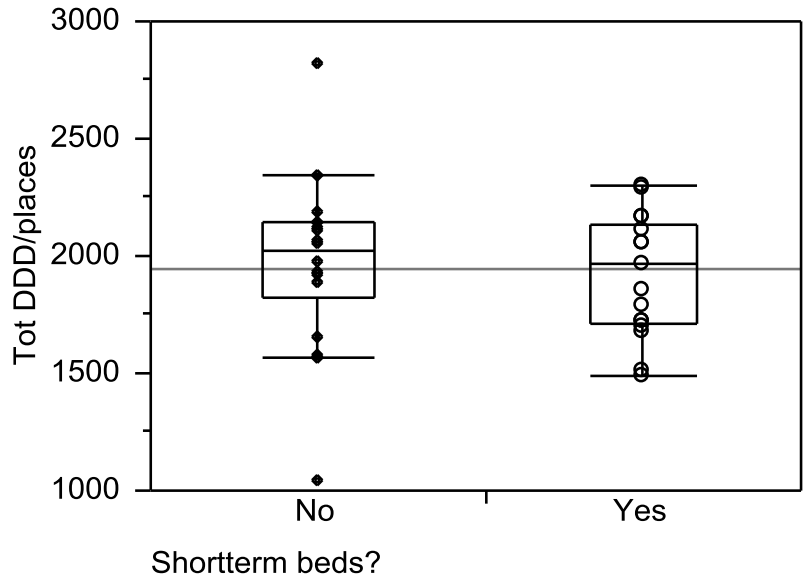


Figure 8. Association between (total yearly orders of drugs per nursing home (DDD))/beds for institutions with short-term beds among 35 nursing homes in Bergen, Norway (Wilcoxon, p = 0.5525). Square marks = institutions without short-term beds, round marks = institutions with short-term beds.

Total DDD/places by short-term bed factor, no short-term beds excluded.

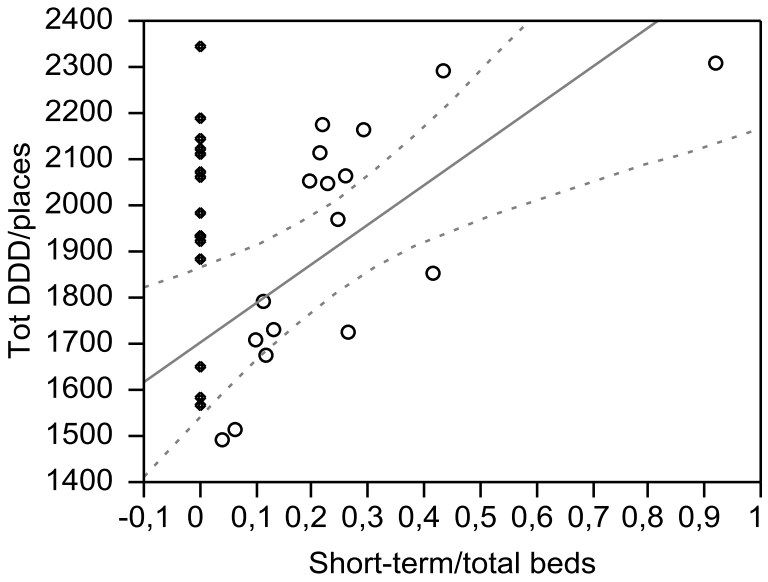


Figure 9. Association between (total yearly orders of drugs per nursing home (DDD))/beds for institutions with/without short-term beds among 35 nursing homes in Bergen, Norway, excluded from analysis institutions without short-term places (p = 0.0027). Square marks = institutions without short-term beds, round marks = institutions with short-term beds.

Calculating the impact of increasing number of short-term beds on the different major ATC drug subgroups, we did not see any correlation for gastro-drugs, nervous system drugs or respiratory system drugs, however a positive correlation existed for cardiovascular drugs (N 35, R^2 = 0.22, p = 0.0042) and antibiotics (N = 35, R^2 = 0.14, p = 0.0262).

We found considerable differences between institutions for all major ATC-groups with regard to total yearly DDD per bed as demonstrated in the figures below.

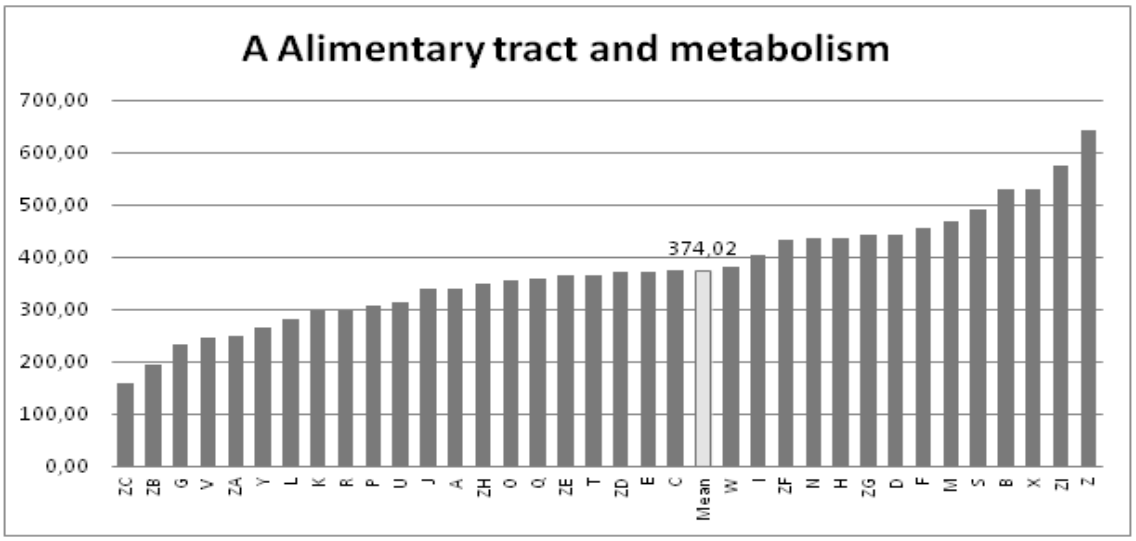


Figure 10. Differences of (total yearly orders of drugs per nursing home (DDD))/beds, ATC-group A, among 35 nursing institutions in Bergen, Norway (max 640.87 min 158.74, mean 374.02, SD 106.56). X-axis, coded names of institutions.

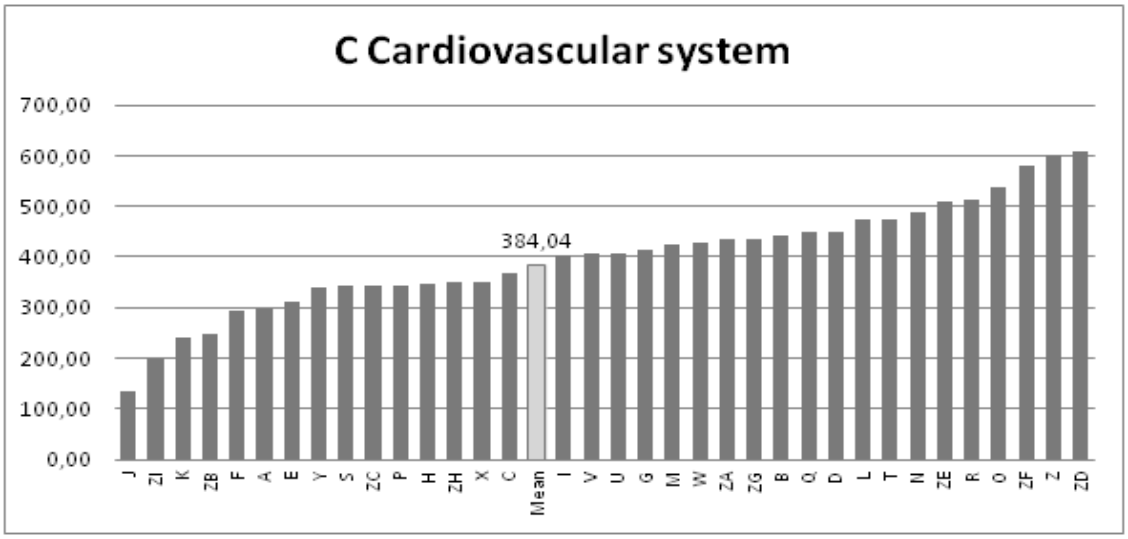


Figure 11. Differences of (total yearly orders of drugs per nursing home (DDD))/beds, ATC-group C, among 35 nursing institutions in Bergen, Norway (max 607.64 min 134.86, mean 399.61, SD 108,63).

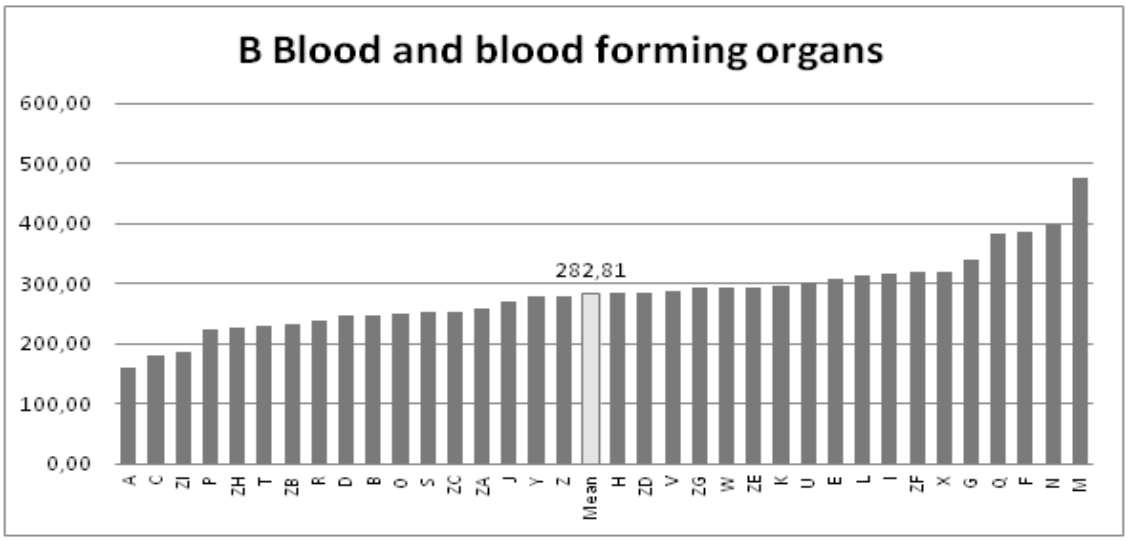


Figure 12. Differences of (total yearly orders of drugs per nursing home (DDD))/beds, ATC-group B, among 35 nursing institutions in Bergen, Norway (max 476.33 min 161.05, mean 282.81, SD 63.23)

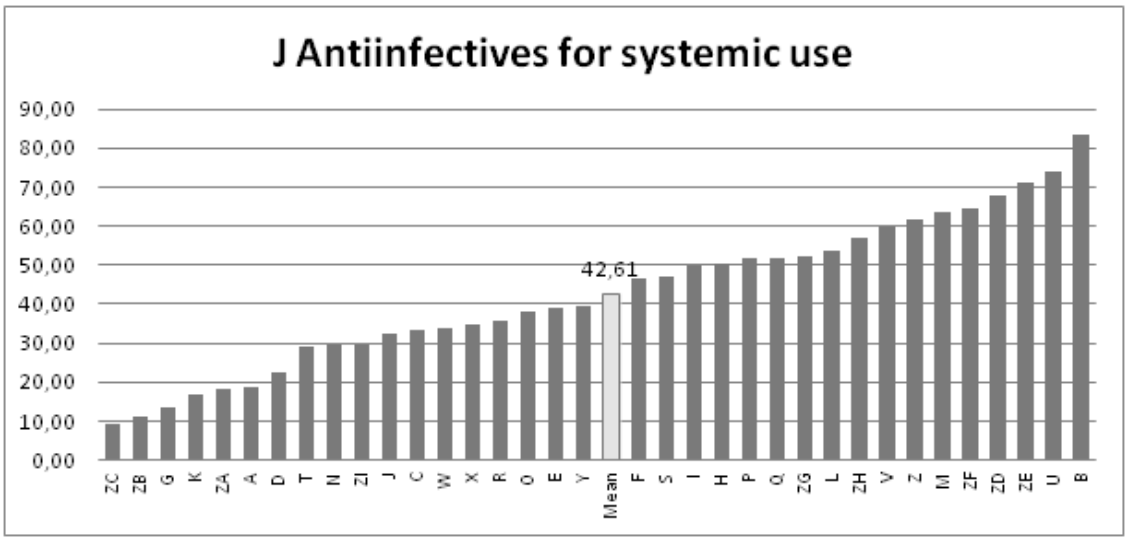


Figure 13. Differences of (total yearly orders of drugs per nursing home (DDD))/beds, ATC-group J, among 35 nursing institutions in Bergen, Norway (max 83.62 min 9.19, mean 42.61, SD 19.27).

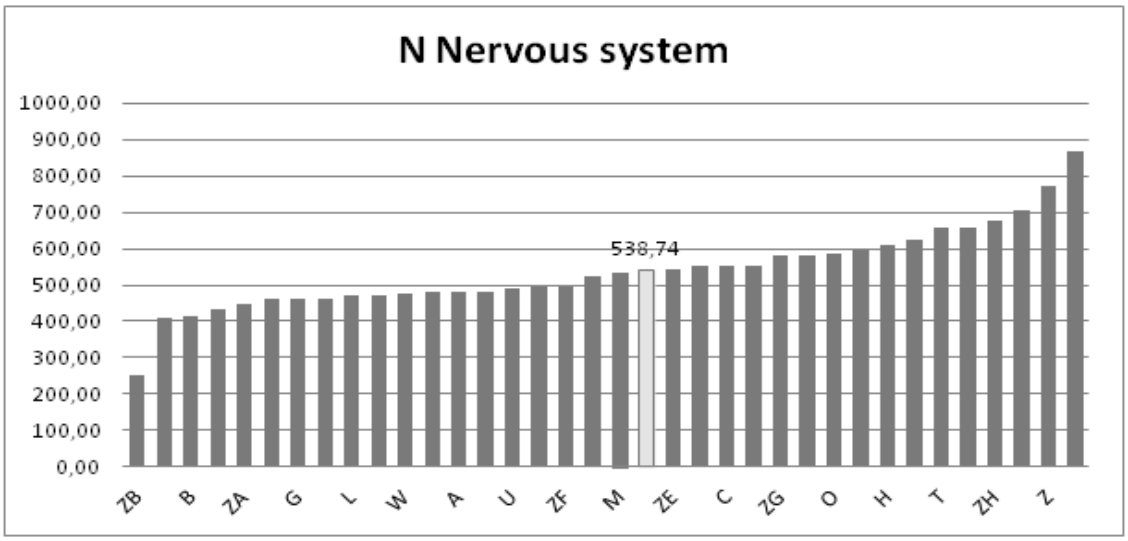


Figure 14. Differences of (total yearly orders of drugs per nursing home (DDD))/beds, ATC-group N, among 35 nursing institutions in Bergen, Norway (max 867.87 min 251.83, mean 538.75, SD 113.87)

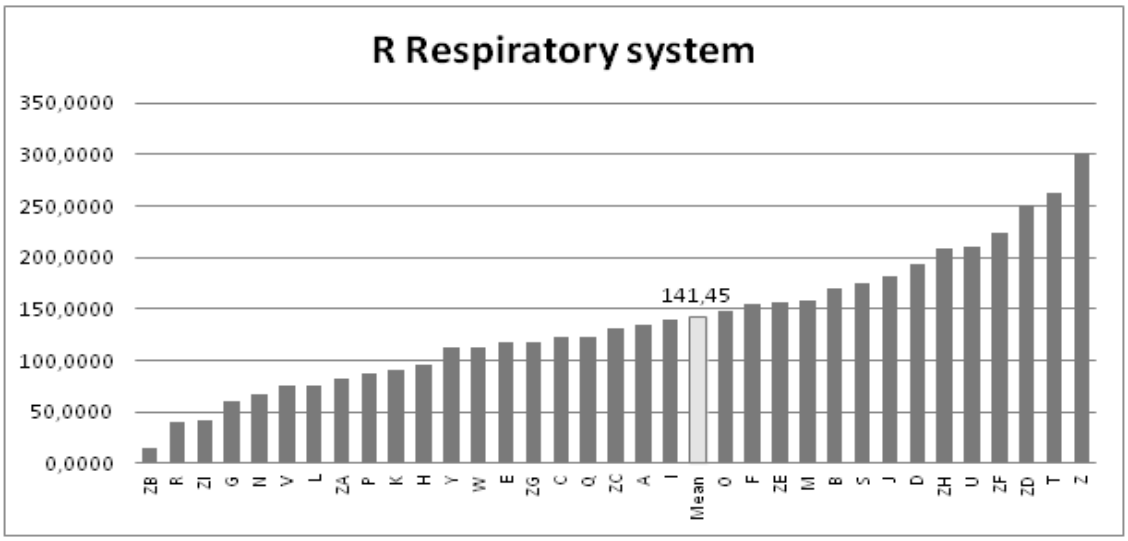
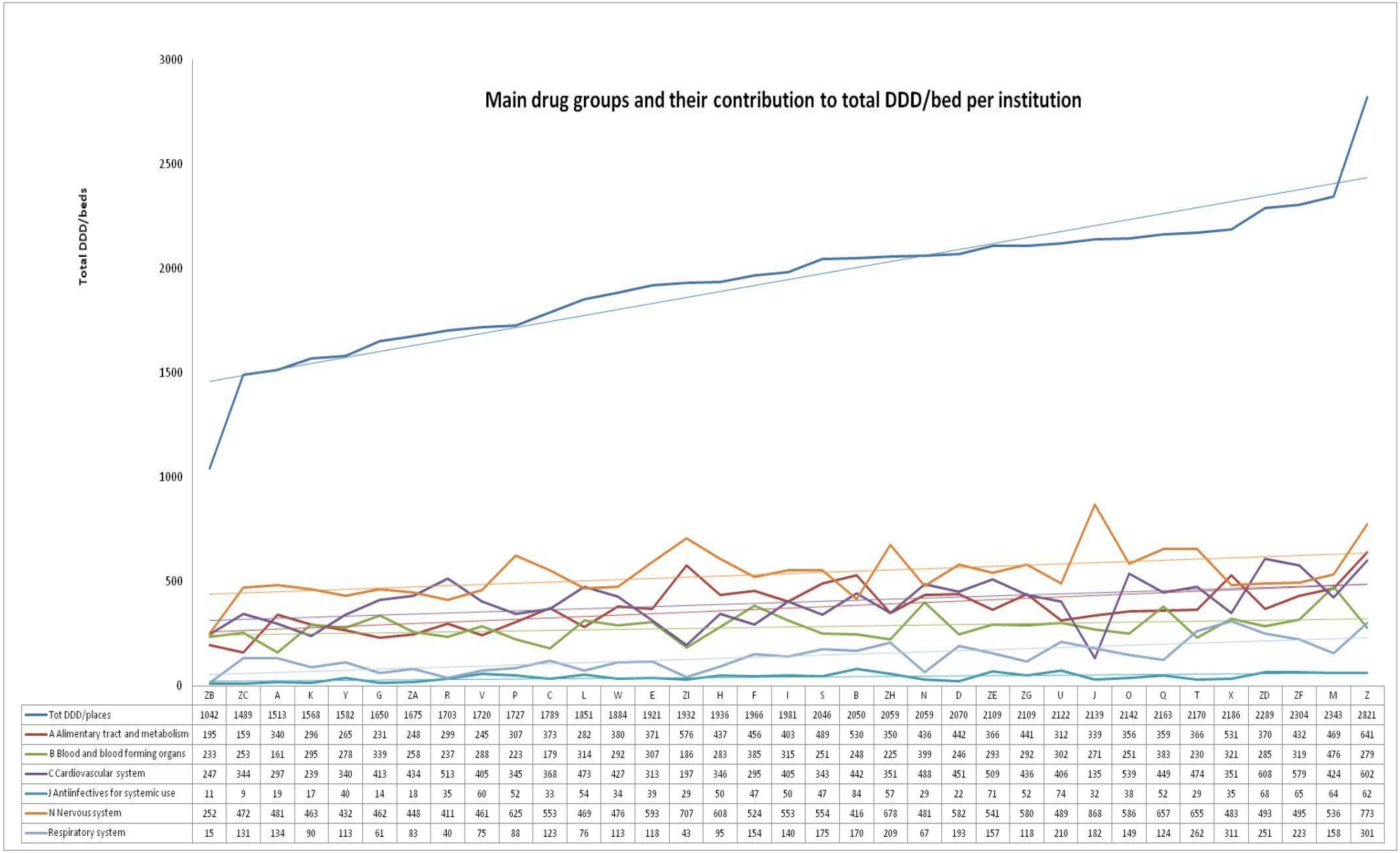


Figure 15. Differences of (total yearly orders of drugs per nursing home (DDD))/beds, ATC-group R, among 35 nursing institutions in Bergen, Norway (max 310.56 min 14.54, mean 141.45, SD 71.78)



	ZB	ZC	A	K	Y	G	ZA	R	V	P	C	L	W	E	ZI	H	F	I	S	B	ZH	N	D	ZE	ZG	U	J	O	Q	T	X	ZD	ZF	M	Z
Tot DDD/places	1042	1489	1513	1568	1582	1650	1675	1703	1720	1727	1789	1851	1884	1921	1932	1936	1966	1981	2046	2050	2059	2059	2070	2109	2109	2122	2139	2142	2163	2170	2186	2289	2304	2343	2821
A Alimentary tract and metabolism	195	159	340	296	265	231	248	299	245	307	373	282	380	371	576	437	456	403	489	530	350	436	442	366	441	312	339	356	359	366	531	370	432	469	641
B Blood and blood forming organs	233	253	161	295	278	339	258	237	288	223	179	314	292	307	186	283	385	315	251	248	225	399	246	293	292	302	271	251	383	230	321	285	319	476	279
C Cardiovascular system	247	344	297	239	340	413	434	513	405	345	368	473	427	313	197	346	295	405	343	442	351	488	451	509	436	406	135	539	449	474	351	608	579	424	602
J Antiinfectives for systemic use	11	9	19	17	40	14	18	35	60	52	33	54	34	39	29	50	47	50	47	84	57	29	22	71	52	74	32	38	52	29	35	68	65	64	62
N Nervous system	252	472	481	463	432	462	448	411	461	625	553	469	476	593	707	608	524	553	554	416	678	481	582	541	580	489	868	586	657	655	483	493	495	536	773
Respiratory system	15	131	134	90	113	61	83	40	75	88	123	76	113	118	43	95	154	140	175	170	209	67	193	157	118	210	182	149	124	262	311	251	223	158	301

Figure 16. The curves demonstrate how the different major ATC drug groups contribute to the total DDD per year and per institution in 35 nursing homes in Bergen, Norway. The institutions (x-axis) are sorted by increasing total DDD per bed.

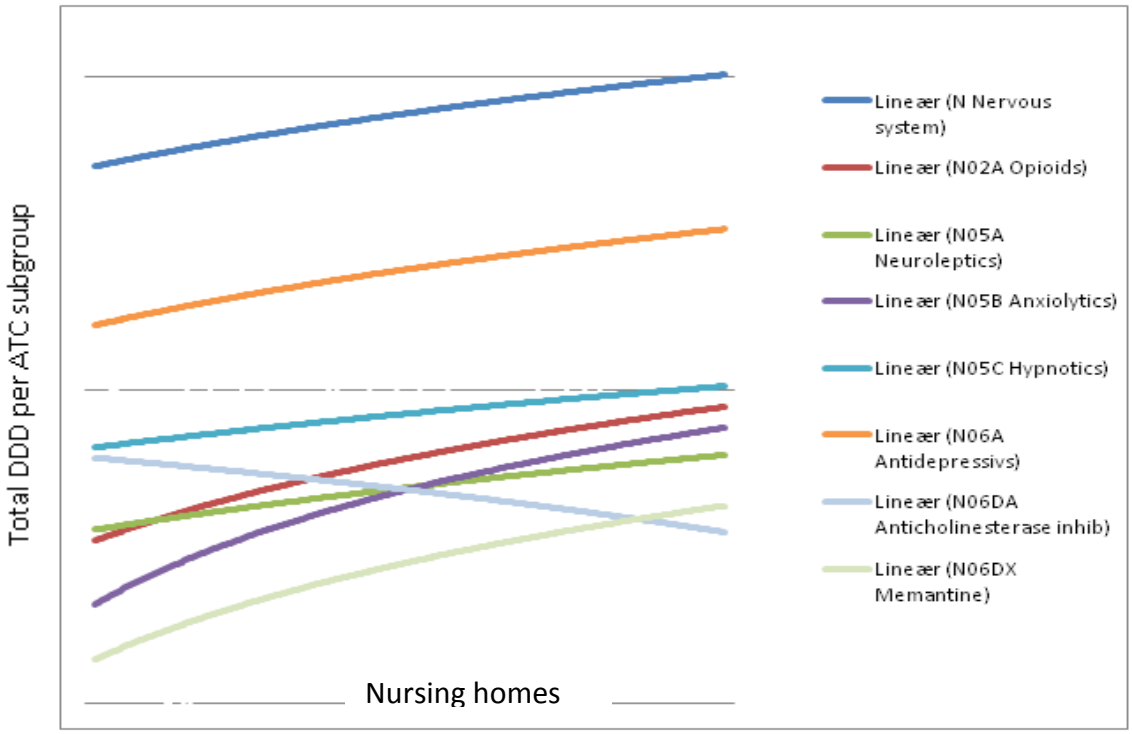


Figure 17. Demonstrates how "nervous system ATC subgroups" contribute to the total nervous system DDD orders per year and bed. The x-axis is log-transformed to increase the visual differences and only the trend-lines for each ATC drug group are shown. The upper blue line refers to (total yearly N-nervous system DDD orders)/beds per institution, sorted according to increasing values. In 35 nursing homes in Bergen, Norway.

Table 2. Total yearly drug orders as DDD's per bed for selected ATC-groups of drugs among 35 nursing homes in Bergen, Norway, 2011.

Institution	Publ0 (K)/Private (P)	Total beds	Long-term beds	Short-term beds	Tot DDD/places	A Alimentary tract and metabolism	B Blood and blood forming organs	C Cardiovascular system	J Antiinfectives for systemic use	N Nervous system	N02A Opioids	N05A Neuroleptics	N05B Anxiolytics	N05C Hypnotics	N06A Antidepressivs	N06DA Anticholinesterase inhib	N06DX Memantine	R Respiratory system
A	P	31	29	2	1512,69	339,90	161,05	297,26	18,74	481,33	38,40	2,19	40,67	43,92	136,13	58,91	16,13	134,19
B	K	100	80	20	2050,21	530,49	247,86	442,18	83,62	415,59	30,33	14,64	15,89	28,85	137,71	32,08	12,14	169,71
C	P	174	154	20	1789,25	373,28	179,16	367,95	33,15	552,73	57,28	22,77	24,41	59,11	159,88	13,39	13,25	122,60
D	P	38	38	0	2069,85	441,72	245,84	450,86	22,28	581,70	37,48	24,27	61,41	74,78	221,71	52,65	2,71	193,16
E	P	82	82	0	1920,86	370,86	307,27	313,07	39,12	593,09	59,28	15,87	50,78	49,54	168,44	54,33	36,91	117,81
F	K	84	63	21	1965,95	455,53	384,69	294,55	46,81	524,27	50,90	49,07	49,85	45,42	154,56	23,84	12,78	154,11
G	K	23	23	0	1650,16	231,27	338,62	412,86	13,52	462,32	11,99	43,60	6,88	96,57	167,39	56,99	0,00	60,72
H	K	60	60	0	1935,70	437,22	283,05	345,76	50,38	608,45	73,11	19,05	45,39	105,58	197,22	9,27	14,92	95,14
I	K	90	90	0	1980,71	402,61	315,48	404,66	49,95	552,59	53,16	38,44	32,44	10,04	194,81	42,59	11,99	140,35
J	K	20	20	0	2139,18	338,53	271,42	134,86	32,41	867,87	57,93	28,91	72,00	160,40	259,48	9,80	22,20	181,84
K	K	34	34	0	1568,37	295,55	295,33	239,38	16,74	462,53	5,54	28,13	45,93	29,45	216,53	46,19	8,09	90,44
L	K	60	35	25	1850,72	282,15	313,84	473,38	53,80	469,28	68,69	25,60	15,61	70,73	128,50	38,13	20,60	75,91
M	P	20	20	0	2343,36	469,05	476,33	423,63	63,51	535,53	24,05	20,68	38,17	97,67	180,20	0,00	15,75	157,82
N	K	107	79	28	2059,21	435,53	398,89	488,24	29,35	481,10	27,80	19,44	16,95	62,88	109,98	43,53	7,94	67,10
O	P	54	54	0	2141,81	355,63	250,95	539,04	37,96	586,22	46,56	80,15	55,85	100,37	179,59	19,65	18,26	148,52
P	K	60	52	8	1727,21	307,45	223,15	344,51	51,62	625,43	55,96	24,69	56,66	24,19	285,62	42,49	13,23	87,52
Q	K	183	129	54	2163,38	359,30	382,62	448,91	51,94	656,76	39,95	40,90	41,39	45,42	223,05	31,11	60,11	123,64
R	P	29	26	3	1702,92	298,67	237,01	513,25	35,49	410,99	17,64	6,74	9,31	83,85	124,22	67,91	0,00	39,83
S	K	131	101	30	2046,40	489,21	251,27	342,50	46,85	553,53	46,41	19,35	20,43	22,85	198,88	31,61	26,37	174,85
T	K	72	56	16	2170,03	366,12	230,34	474,12	28,89	655,02	35,31	107,98	27,95	60,42	125,83	42,81	52,75	261,84
U	K	30	30	0	2121,77	312,23	301,57	405,56	73,98	489,45	31,05	6,82	24,75	24,33	193,80	18,23	49,97	210,29
V	K	64	47	17	1719,74	245,02	288,09	405,16	59,93	460,86	43,26	25,35	28,84	74,97	162,37	4,78	25,59	75,24
W	P	36	36	0	1883,75	379,58	292,38	426,71	33,75	475,80	45,18	14,02	20,94	38,94	179,59	33,95	16,89	113,16
X	K	30	30	0	2186,28	530,57	320,57	351,13	34,85	482,83	42,60	14,86	28,00	48,00	145,21	78,09	27,03	310,56
Y	P	34	34	0	1581,93	265,00	278,10	340,27	39,70	431,53	52,35	58,85	21,26	51,97	89,78	36,12	0,00	113,09
Z	P	27	27	0	2821,08	640,87	278,72	601,96	61,58	772,96	89,49	12,87	34,01	76,91	334,07	20,34	13,56	301,36
ZA	K	25	22	3	1674,64	248,42	258,46	433,59	18,03	448,33	12,58	86,36	35,28	5,60	152,47	30,30	10,72	82,81
ZB	P	24	24	0	1042,35	195,34	233,39	247,47	11,39	251,83	7,21	19,08	17,88	19,78	86,45	26,28	20,39	14,54
ZC	P	46	44	2	1489,42	158,74	253,42	343,57	9,19	472,37	13,85	53,59	18,70	87,21	149,26	57,90	49,13	131,20
ZD	K	53	30	23	2288,53	369,98	284,86	607,64	67,98	492,88	60,89	12,01	17,17	87,10	103,04	18,91	4,21	250,95
ZE	K	65	51	14	2108,55	365,63	292,97	508,95	71,31	541,36	70,16	13,57	48,24	79,22	143,30	35,57	9,85	156,86
ZF	K	64	5	59	2304,22	432,15	318,79	579,34	64,69	494,69	52,40	16,09	21,86	86,84	116,10	30,25	7,81	223,35
ZG	K	64	64	0	2108,61	441,14	291,78	436,38	52,22	580,20	26,99	134,38	22,55	11,96	166,20	28,45	13,42	118,42
ZH	K	74	74	0	2058,80	350,24	225,11	350,69	57,21	677,54	67,24	54,96	37,25	35,39	214,12	17,14	56,81	209,14
ZI	K	60	60	0	1931,75	575,70	185,78	196,93	29,42	707,10	41,44	48,67	82,56	71,46	191,60	26,83	23,75	42,55

Weight related results

A total of 488/513 of the patients (95.1%) were weighed, the average weight being calculated as 62.03 kg (SD = 14.38, min. 30.1, max. 118.7). The previous weight of 431/513 (82.7%) of the patients was found in patient records, the average weight being 62.9 kg (SD = 14.65, min. = 30, max. = 124). Women had an average weight of 58.8 kg and men 69.1 kg.

On average 125.1 days (N = 416) had passed between control weigh-ins.

Significant differences were found between nursing homes regarding proportion patients weighed last 30 days (Pearson, $p < 0.0001$), corrected for "length of stay".

In the two institutions participating in the before-after intervention study 72.6% of patients had not been weighed last 30 days. The average for all institutions was 52%.

Discussion - primary objectives

The role of nursing homes in the delivery of social and health care services differs between, as well as within, countries [94]. Nursing homes in many countries are managed as part of social care. These differences may influence the health issue landscape and composition of staff. Thus comparisons and generalizations based on our findings should be done with care.

Discussion of the intervention study

Publication 4.

Due to an unforeseen decision by the county administration, which made a few months extension of the study impossible, the material turned smaller and weaker than planned. We are well aware of this fact, but decided to publish the results despite this, since we were able to test the hypothesis by different methods. Firm scientific proof is however not presented by this study.

Endpoints changed significantly during intervention by increased use of warfarin, decreased use of neuroleptics and a higher weighing rate. Job satisfaction was not adversely affected.

The methods for evaluating change and improvement strategies are not well described. Such study designs should generally be used in a context where they build on appropriate theoretical, qualitative and modeling work, particularly in the development of appropriate interventions [95]. We feel we have properly documented the fields in need of improvement and thus study objectives.

Baseline and follow-up data for the first cross-sectional sample were collected, by the prevalence study (before) and (in the case of the second sample) after the intervention, respectively. As it was not possible to collect follow-up data for everyone included in the first study (for political reasons), and the patients included in the second sample were not identical to those in the first due to deaths, the two samples were compared using methods for comparing unpaired data. This *is* a weakness, but to compensate for the 40% or so annual death rate in nursing homes, the sample size would have had to be much higher to be able to use patients as their own controls, and this may not have been advisable when testing front-end technology in the first study.

Our design must be seen in light of the immaturity of research in nursing homes in general. As far as we know, neither recent data exist on the prevalence of atrial fibrillation in a nursing

home population and the use of warfarin, nor is information available on how well basic procedures like weighing are conducted. More information has been available on the use of neuroleptics. There was therefore a need to do a prevalence study, define valid endpoints and to do an intervention study. It may be claimed that we should have separated the tasks, but nursing homes are in great need of improvement strategies and time is short before the elderly wave is set to impact heavily on nursing home demands. Financial and political limitations played a role too, obstructing any possibility of performing a full-scale follow-up study. But conversely, it would have been a challenge, in a randomized trial within one municipality, albeit with 37 institutions to choose from, to avoid study group pollution and the "Hawthorne effect" [95, 96]. Starting out with a comprehensive and expensive randomized study would probably not have been ethical due to all the uncertainty and possible threats from new information technology systems, and hence probably difficult to fund. When we started, we did not know if it was possible to install the application, educate and prepare for critical daily use in 7 institutions with 500 to 800 users within a timeframe of 4 months. Looking back, this may be regarded as the most convincing result of the project.

We used a design where we evaluated endpoints in a before-after study with internal controls [91-93]. The stability of internal controls throughout the intervention reinforces the internal validity of the study.

With the technology presented, effects can be measured continuously. However, we cannot conclude the extent to which the technical aspect or "awareness of the performance process" is responsible, through education, for the changes measured. Yet without any performance figures it is not possible to focus on changing processes, so the two ways of influencing results are not independent factors.

The technology made it possible to monitor performance without time-consuming traditional studies and made performance feedback possible. This is a relatively new concept in medical research, made possible by structured medical input applicable to automatic and continuous analysis. Consequently, the proportion of patients taking neuroleptics could also be followed using time-series, giving more detailed information about the changing process and strengthening the validity of the effect results. As a critical information element, drugs were punched into each patient record at an early stage of the implementation process and this gave us a sufficient "before-point" on the time-series. We discovered that the significant change in

the before-after study was due to only one of the participating institutions, and that this institution showed up a clear brake in the curve at the point of intervention start-up.

Concerns about structuring medical templates do exist. Some claim that the templates do not simply document the task but change the nature of the work and lead to ‘institution-centered’ care over patient-centered care [97]. In our view it is not possible to structure all information in electronic medical records. All structured forms therefore should have unlimited free-text option. Structuring information should have a clear predefined purpose defined as an alarm, a statistic or a definition of a population. Templates may also be structured in the sense of structured "questions" but free-text "answers" and may this way serve as important reminder notes. This reduces information gaps due to employee knowledge differences. We however support the view that more research is needed.

Some authors claim that decision support applications may introduce unexpected errors, mainly in the process of entering and retrieving information, and in the communication and coordination process that the Patient Care Information Systems (PCIS) is supposed to support [98-100]."- Factors that could diminish information and communication technology (ICT) harm, include adoption of common standards, technology maturity, better system development, testing, implementation and end user training. Factors that will increase harm rates include complexity and heterogeneity of systems and their interfaces, rapid implementation and poor training of users" [101].

It is of course important to be aware of these circumstances as even increased mortality has been proven after introducing new technology [102]. Keeping updated on new knowledge is important when constructing new systems and studies to minimize unexpected consequences. It would however be in opposition to common logic to make these cautions prevent introducing carefully designed electronic systems.

Discussion - secondary objectives

Discussion of the hospitalization study

Publication 1.

We estimated that close to 100% of the admissions from nursing homes (A) take place using the ambulance service and therefore consider the basic material reliable. However, it contains no information about the degree of general debilitation or the degree of dementia. This is a weakness. It is difficult to decide whether or not the admissions were unnecessary. The material is too superficial for that. An indication of co-morbidity is given by numbers of secondary diagnosis, which range from 0 to 9, averaging 2.9. Our project only had access to anonymous data and could not count re-admissions, therefore. This strengthens the material in a patient and data security perspective, but calls for further research. It has previously been shown that infections are the most common causes of hospital admissions from nursing homes [103-105]. This is confirmed by our results [103, 106-110].

Some may claim that the number of observations is low with regard to the regression analysis (32/15 institutions). We are however inclined to think that institutions are less volatile then individuals, especially as all of them in this study are within the same county and are administered by the same management and thus are similar with regard to nursing factor, reimbursement, level of education etc. The included institutions cover 91% of all nursing homes within the county which secures validity within this population.

As clearly shown in the publication, two of the nursing homes are outliers by their extra high short-term factor and doctor employment factor. Both factors seem to be correlated to increased number of hospitalizations. We therefore performed a multiple regression analysis of all admissions in 2007, both with and without the outliers included, containing both doctor employment factor (t), short/long-ratio (r) and a factor if the institution had short-term beds at all (k);

$A = b_0 + b_1t + b_2k + b_3kr$, i.e.

if $k = 0$ (no short-term beds): $A = b_0 + b_1t$, and

if $k = 1$ (with short-term beds): $A = b_0 + b_1t + b_2 + b_3r$.

A = 25.047 -0.690t+ 21.676k + 6.730kr, which means that there is no effect of doctor employment factor (t) corrected for short-term/long-term factor (p = 0.942). If k = 0 (no short-term beds): A = 25.047-0.690t, if k = 1 (with short-term beds): A = 25.047-0.690t + 21.676+ 6.730r. The analysis was repeated with two nursing homes with extremely high doctor employment factor excluded (p = 0.280).

In other words: Nursing homes with short-term beds have more hospitalizations and the number increases with increasing short-/long-term ratio even when adjusted for varying doctor employment factor. Also when including the interaction between k and t in the analysis, the result is very similar, and we thus have no reason to believe that doctor employment factor has different impact on hospital admissions from nursing homes with and without short-term beds.

The results above refer to the analysis with all 32 institutions included. Excluding the two outliers from the analysis leaves no significant results at all. It is no clear-cut answer to the question if the two outliers should be included in the analysis or not. They are atypical due to high employment factor, on the other hand it is the effect of the employment factor we intend to examine and the other institutions do not vary enough in their employment factor to evaluate the effect if excluding the two highest values. It is a well known principle by the regression analysis that spread values along the x-axis strengthens the analysis. We do not see other differences between the two outliers and the other nursing homes which should considerably impact the result.

We also performed residual analysis for the regression analysis to check if there are reasons to assume differences from expected normal distribution. We did not find deviations which should impact the referred results.

So we conclude that increasing short-term bed factor increases hospital admissions and that increasing doctor employment factor does not reduce hospitalizations significantly. The results are consistent even analyzing subgroups of nursing homes, for example big/small.

Discussion of the clinical prevalence studies

Publications 2 and 3.

For most planned purposes we consider our material valid and robust with regard to both sample size and tested parameters. However, the size of the material may be too small to calculate the prevalence of rarer diagnoses/drugs. A weakness of our study is that comparisons between diagnosis and drug treatment cannot be performed. The simple test we used to decide whether or not patients had reduced cognitive functions can be questioned [88]. Using Minimal Mental Score was beyond project resources. Our method was to a certain degree validated, however, by comparing the extent to which dementia drugs were given to patients scoring above 0 (reduced cognitive functions), giving a 95% overlap, and to a certain degree by medical record data. We thus found our method sufficient for the purposes of the study.

We found good concordance with results from previous studies in terms of the drug groups most frequently prescribed (N, A, C, B, R) [111]. The decreasing use of neuroleptics in nursing homes discussed by other authors has not been verified [48].

In our study we have demonstrated sizable differences between the nursing homes when it comes to the use of medications, which cannot be explained by different prevalence alone. Calculating the total use of drugs within each drug class using DDDs, increased the differences between institutions. This probably shows that institutions with a high percentage use even are using higher dosages. To examine treatment differences between nursing homes even further we analyzed the yearly sales statistics. The sales statistic file from vendor gives total and comprehensive information on drug orders from all nursing homes in Bergen. The total yearly figures are based on multiple orders (i.e. weekly) for each institution and there is thus reason to believe that the figures give reasonably representation of total drug use. The results confirm the results from the article on psychoactive drugs in seven nursing homes. There are considerable differences in drug use between institutions, which, as far as we consider, cannot be explained by prevalence differences.

We found that 18.8% (91) of the patients had AF in our study population. The prevalence of AF has been found to be 17% for patients over 65 years and to increase with age [112]. Our prevalence is comparable to earlier findings and age groups. Patients with AF older than 65 have been consistently undertreated with anticoagulants [113]. This is consistent with our

finding that the warfarin treatment rate was low (14.3%). Even a warfarin treatment rate of about 65% of elderly AF-patients is considered problematic by several authors [73, 114]. In our study, we found a significant increase in stroke prevalence in AF patients not treated with warfarin, which illustrates under-treatment. Reasons for low treatment rates might be fear of intracranial haemorrhage and falls [114] but with systematic monitoring the risks associated with oral anticoagulation treatment appears to be low [115]. To start life-prolonging treatments may not always be as obvious to do in nursing home patients compared to younger patient groups. Suffering involved with stroke is considerable however, and should be prevented if possible, at all ages.

Based on our estimates the stroke risk among nursing home residents with AF was 8.5 – 18.2%, considerably above 5.6% which is considered the highest bleeding risk score according to Shireman et al. [73]. Increased risk of bleeding episodes on warfarin treatment usually occurs among the elders aged within two months of start-up [116]. On the other hand, increased CHADS2 score (4-6) in the oldest (>85) population may increase bleeding risk [117]. Treatment must always be individualized therefore.

McCormick et al. [118] found that AF was present in 429 (17%) of 2,587 long-term care residents. Overall, 42% of these AF patients were receiving warfarin. This is consistent with our study when it comes to AF prevalence and more in line with our own opinion of a reasonable treatment level of frail nursing home patients than our own findings.

It may be claimed that using ProBNP as the only parameter to diagnose insufficiently or non-treated heart failure weakens the study and most procedures in force recommend echocardiogram to diagnose heart failure. On the other hand, an echocardiogram is often impractical as a diagnostic tool for nursing home patients both due to equipment price and physician qualifications. Transporting patients to a specialist cannot always be recommended for these frail patients either.

The cut-off value of ProBNP as a diagnostic tool for heart-failure in need of treatment, in different populations, is a matter of discussion. The high median age in our cohort made us go for a relatively high cut-off value (as increasing age leads to increasing ProBNP levels) even though that weakened sensitivity of the test. The main purpose of our study was however to examine if under-treatment existed in heart failure patients. Therefore, specificity (the proportion of negatives in the test which are correctly identified) was more important than sensitivity (proportion of actual positives which are correctly identified). – We needed to be

fairly sure to exclude healthy patients, missing some sick patients however, strengthens the under-treatment conclusion.

The identified risk by elevated ProBNP, whether it's a risk for death or a risk for heart failure hospitalization, lower values are better, higher values are worse. What one also knows, based on the data from Val-HeFT, is that while a single measurement is useful, serial measurements seem to inform even better prognostic value. This also refers to patients above 75 [119-121].

Cut-off limits of ProBNP as a diagnostic and prognostic tool in heart failure are discussed in numerous studies. In one study (mean age 73 years, followed for 6 years and registering all cardiovascular mortality) persons with ProBNP above 200 pmol/l had higher mortality [122]. In another study, 24 out of 25 patients were classified correctly with regard to heart failure, as compared with cardiac echo, using a ProBNP cut-off of 223 pmol/l [123].

Our results of bivariate fits of ProBNP by eGFR, weight and age (which are the known biasing factors), lead us to the conclusion that nursing home patients with a ProBNP > 225 pmol/l were more likely to have heart failure and, above this level, the high ProBNP values were not caused by high age, low weight or renal failure.

We found 13.2% (59) had a higher ProBNP (> 225 pmol/l). 8 - 10% was the prevalence rate for heart failure in earlier studies [124]. Only ten (16.7%) of the patients were given both ACE/A2B and diuretics, which suggests under-treatment. This impression is reinforced by the lack of significant ACE/A2B differences in treatment rates between the patient group with high ProBNP and normal renal function (eGFR > 60 ml/min – giving a therapeutic indication without renal contraindication) compared to the rest of the cohort.

A high proportion of renal failure among the elderly has been considered to engender reservations in prescribing ACE inhibitors for this patient group [125]. However, it is not appropriate to withhold ACE inhibitors for heart failure in patients with only mild renal failure [126, 127]. Our findings show a low treatment rate in patients with adequate renal function as well.

"Healthcare administration through structured records" (HATS)

Based on our total work our belief in structured medical records, as a way to audit and improve medical quality, has increased. We think there are reasons to examine this further in future projects. This may prove advantageous for healthcare as such, as this kind of electronic infrastructure can add clinical variables to the management of health institutions by means of "New Public Management" [128-133].

New Public Management (NPM)

The start of the New Public Management (NPM) as the wave of reform for the public sector has its origins in Australia (1983) and New Zealand (1984). Behind the NPM is the criticism of an inefficient public sector. "NPM has thus been a reform wave with a core idea, but with varying and inconsistent implementation in different countries. It has had strong coalitions behind in many countries, coalitions that are now beginning to fade. It has been characterized by a one-dimensional and economically-oriented thinking, and led to efficiency gains, but also weakened the political control and increased bureaucracy. It has now been supplemented and modified by post-NPM reforms in many countries, characterized by less emphasis on efficiency thinking and more emphasis on the management and coordination" [134].

NPM criticism

The more specific criticism against NPM, as it is reflected in various government scientific studies, is that the NPM is far too one-dimensional efficiency-oriented. "Efficiency is important, but must be balanced against other important and legitimate concerns in the public" [135]. "A main point is that this type of thinking is underdeveloped when it comes to insight into the structural design in the public and that the reform elements that come from the different types of theory is partly poorly justified and partially encounter against the other, so that the result is complex and hybrid structural solutions" [134]. One of the early writers of NPM identified several ways in which public organizations differ from the private sector[1]. He also identifies that the reform tends to ignore these differences [136].

[1]

- degree of market exposure—reliance on appropriations
- legal, formal constraints—courts, legislature, hierarchy
- subject to political influences
- coerciveness—many state activities unavoidable, monopolistic
- breadth of impact
- subject to public scrutiny
- complexity of objectives, evaluation and decision criteria

The most obvious sign of NPM in the Norwegian health care system is probably the activity based financing in both first- and second line services and especially the DRG-system (Diagnosis-related group) in the hospitals. Market models were difficult to apply without the goods and commodity prices. It was therefore constructed an artificial list of priced "products". The DRG-system has been continuously changed and refined the last 30 years to try to make it comprehensive and correct despite the difficulties to estimate cost of production of the "products" due to the tremendous complexity of the task. The critics of NPM in Norway are moderate, but exist, especially from the left sided politicians. The criticism is directed mainly against the market thinking as such and not more analytical, - towards the system-design.

"Unit Price-funding has already led to increased class differences between patients. It has therefore been a shift towards the profitable patients at the expense of the unprofitable. Health workers react already today strongly against the health care system becomes more money-oriented, as we have also seen it in other countries with similar model. Unit price system leads to an increased need for management" [137]. Some are not gracious in their criticism; "The results are inefficiency, poor service, red tape and frustrated employees" [138].

Norwegian health authorities however perform a sober view of the DRG system and the activity-based portion of the financing (financing consists of a framework financing part and an activity-based part) indicated by a declining activity-based proportion the later years (now about 25%) and plans to maintain this level [139].

Medical diagnosis is no clear-cut procedure, and it is likely that DRG coding affects the diagnosis. DRG coding changes the system to describe. A diagnosis is not the result of standardized practical patterns. Review of patient records shows that there is relatively poor correlation between what is documented in the records and how this is expressed through codes. Thus, the system will never be so robust that it generates activity statistics as detailed and valid as expected by the authorities [140]. The constant changes in the activity-based financing and DRG code setting is perceived problematic by the doctors. - The coding is time

- authority relations and the role of managers
- organisational performance
- incentives and incentive structures
- personal characteristics of employees

consuming and it feels bureaucratic, especially as extra employees are appointed in order to check whether the codes are correct [141].

New trends

Some authors claim NPM has peaked and is now in decline. Critics like Dunleavy now proclaim that "NPM is 'dead' and argue that the cutting edge of change has moved on to digital era governance (DEG), focusing on reintegrating concerns into government control, holistic (or joined-up) government and digitalization". "The character of the post-NPM regime is currently being formed. A range of connected and information technology–centred changes will be critical for the current and next wave of change. The overall movement incorporating these new shifts is toward ''digital-era governance'' (DEG), which involves reintegrating functions into the governmental sphere, adopting holistic and needs-oriented structures, and progressing digitalization of administrative processes. DEG offers a perhaps unique opportunity to create self-sustaining change, in a broad range of closely connected technological, organizational, cultural, and social effects" [142].

Dunleavy defines characteristics of NPM within three main categories[2]. He consider interestingly only a few of these factors still to be in force in NPM-countries, namely the factors regarding "improved performance measurement", "league tables of agency performance", "user control", "unified rate of return and discounting", "development of charging technologies", "valuing public sector equity" and "mandatory efficiency dividends".

[2]

1. Disaggregation

Purchaser-provider separation; Agencification; Decoupling policy systems; Growth of quasi-government agencies; Separation out of micro-local agencies; Chunking up privatized industries; Corporatization and strong single organization management; De-professionalization; Competition by comparison; Improved performance measurement; League tables of agency performance;

2. Competition

Quasi-markets; Voucher schemes; Outsourcing; Compulsory market testing; Intragovernment contracting; Public/private sectoral polarization; Product market liberalization; Deregulation; Consumer-tagged financing; User control.

3. Incentivization

Respecifying property rights; Light touch regulation; Capital market involvement in projects; Privatizing asset ownership; Anti-rent-seeking measures; De-privileging professions; Performance-related pay; PFI (private finance initiative); Public-private partnerships; Unified rate of return and discounting; Development of charging technologies; Valuing public sector equity; Mandatory efficiency dividends.

Motivation and productivity

Fauli discussed in 2010, in an article in the Journal of the Norwegian Medical Association, interesting aspects of the health workers' motivation and linked this to the design of reward systems. "The Swiss welfare economist Bruno Frey believes that human beings have an intrinsic motivation."Crowding-out" theory means that the use of incentives that affect the individual's external motivation can reduce their intrinsic motivation. External motivation represents the incentives coming from outside, the recognition, reward or punishment. According to this theory is monitoring considered a signal of lack of trust, and can reduce the intrinsic motivation. With regard to reimbursement systems, Fauli is inclined to think that the goal must be to find a form that provides the best quality of care within budget, with minimal adverse effects. She therefore suggests a neutral reimbursement system and rather improving the quality of treatment by measures that strengthen the quality of doctor's work. Examples are voluntary participation in quality registries, with regular feedback of your own activity compared to colleagues 'activity' [143].

In a management theoretical perspective, this may be seen somewhat different. While the medical logic is rooted in duty ethics, where the interests of the individual are in focus, the financial/administrative logic is based on the "new ethics" or utilitarianism, where efforts are evaluated in a cost benefit perspective. The question is whether the introduction of NPM-inspired reform measures can lead to value conflicts for doctors and nurses, where they have to take into account both what is best for the individual and what will be the benefits to society. Doctors and nurses "both serve as good Samaritan to the individual patient and as a judge towards the community's needs" [144].

Does this have any relevance to the assessments of what is wrong with NPM in its original form? The basic idea of NPM seems to be judged as reasonable, but that the gap between real markets and the healthcare "pseudo market" is too big. The genuine medical production elements do not fit properly the parameters needed to apply market theory. It all turned unfavourable due to shortcomings in productivity- and incentive parameters. Instead of auditing "the percentage of procedures without complications" one measured "number of procedures", and thus introduced an incentive system not matching the wished goals and leading to unmotivated employees.

When it comes to Norwegian nursing homes the situation is partly different from the hospitals as the DRG-system is not used in the governance of nursing homes in the municipalities, and

depending on which political party is in power, it vary to which extent performance-based financing has been implemented [145]. On the other hand, the production of patient focused quality parameters is absent and the medical record systems are not constructed in a way which makes such production possible [146]. The possibility of rational self auditing, as mentioned by Fauli as a quality improving method, is therefore not possible.

When it comes to production of quality indicators (QI) it is preferable that the data retrieved for QIs are obtained by data that already exist, and that data collection for QIs does not mean extra workload for health personnel [147]. Easily retrieved data from the patients' records is an example of such data for quality indicators (QI) [148]. Tools to ease the use of QIs in clinical settings need to be developed [149]. The Norwegian national system for care statistics (IPLOS) does not comply with these demands [150].

We are inclined to think thus, that the major NPM weaknesses, which seems to be production of user-centred and valid performance statistics and quality indicators, relates both to Norwegian first- and second line health services.

The missing NPM link?

The question arises then, with reference to the factors discussed above, if it is possible to feed the remaining foundations of NPM with digitally-based management tools (DEG) in the form of user centred (to meet Bruno Frey) quality parameters that motivates health workers and thereby fosters quality improvements and increased productivity? The goal might be to "develop a system that makes it possible, through the year, to have full control of what is performed and what resources are used" [151]. Our own work and thinking tries to evaluate if there is reasons to believe that implementing structured medical recording may be a way to reach these goals. And decision support is closely correlated with structured record information, because the decision support tools have to respond to information in the record. This is easier to accomplish if the underlying data are structured [26].

So, if the medical, electronic health record systems are containing structured medical and administrative parameters, which have a patient-centred origin, it is possible to design quality parameters, which may motivate health workers, and to monitor these continuously.

It is important to underline the difference between the system which can produce and audit quality parameters and, on the other hand, the process of finally decide which quality parameters to implement on a broader scale, which is not always a straight forward process as

the measure for good result or success has to be agreed upon, and evidenced-based processes and structures that underlie the result must be documented. Measurable indicators derived from this procedure must be tested in a scientific manner for relevance to nursing home care quality and patient-centeredness, reliability in the way it is obtained, comparability between facilities, ability of clear interpretation and whether the indicator can be influenced by improving quality [149]. In this regard clinical medicine is probably easier to assess than nursing, as parameters for scientifically tested "good clinical practice" is already available (i.e. "patients with eGFR < 50 ml/min shall not be treated with methformin due to danger of worsening renal failure". No doctors would argue against this medical knowledge).

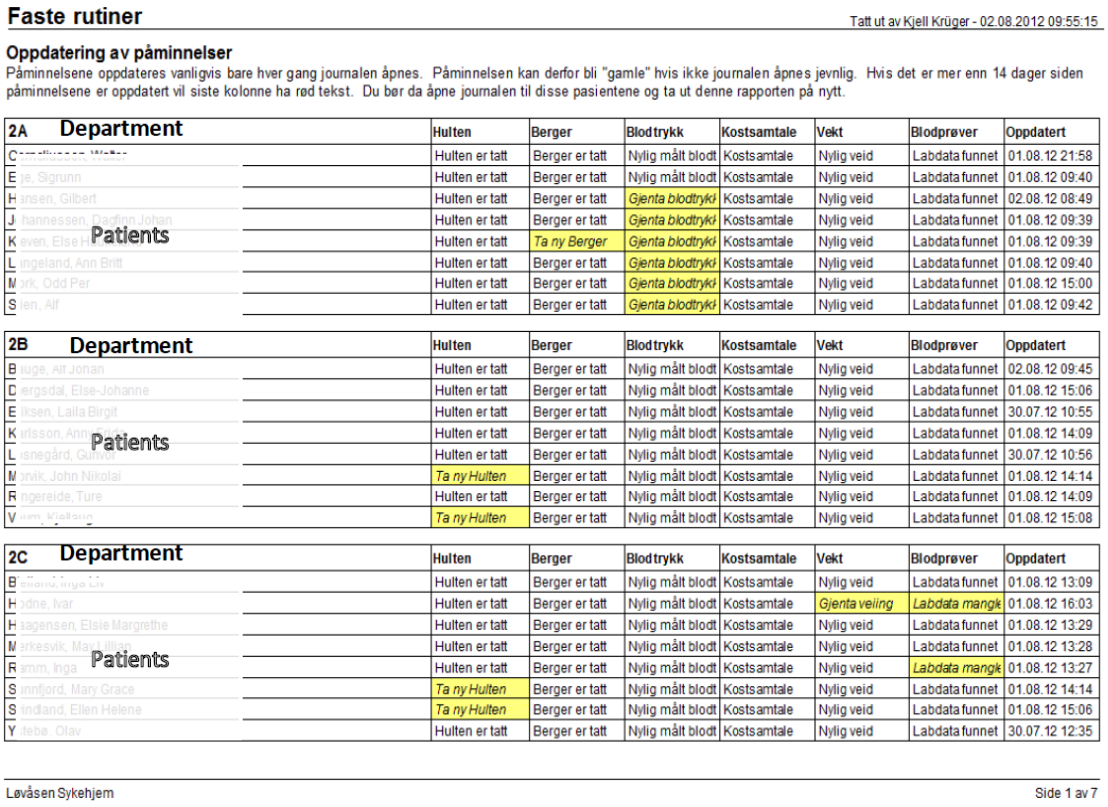
The **table 3** below shows the subpopulations and alarms defined in the test-system. Some of these may be used as quality indicators after proper evaluation. At the department and institution level the **figures 18 and 19** below demonstrates examples of reports which give concrete feed-back to the users about performance and statistics.

Although self-monitoring probably is most effective in quality improvement efforts, few will argue that management and authorities should waive their rights of monitoring selected quality- and productivity parameters. In structured electronic medical records, based on basic datasets, this may be done continuously and electronically, as shown below where the percentages of patients using different groups of drugs are compared between institutions [152]. **Figure 20**.

Table 3. The table demonstrates filters and alarms defined in the medical record system which has been tested. The system was tested for ability to impact clinical variables in 7 nursing homes in Bergen, Norway.

Subpopulations defined in UNO GBD	Alerts*
Medical alerts	
Not weighed the last month	X
Pathologic MUST score (nutrition status)	X
Weight loss above 5% last 6 months	X
Patients taking antihypertensive drugs and the last BP is below 120 systolic	X
Patients with dementia using drugs with anticholinergic effect	X
Patients using ACEI or A2B and having an eGFR < 60 ml/min	X
Patients with proBNP > 225 pmol/l	X
All patients with proBNP> 225 not using ACEI or A2B	X
Patients with drug interactions within the RED risk level (DRUID)	X
Patients with drug interactions within red and yellow risk level (DRUID)	X
Patients on medications used for Parkinson's disease using neuroleptics	X
Patients on both NSAIDs and warfarin	X
Administrative alerts	
Patient not taken Berger dementia scores last 6 months	X
Patient not measured BP last 60 days	X
Patient not taken the ECG last 6 months	X
Patient not taken Hultén nursing load score last 3 months	X
Patient without medical notesby doctor last 90 days	X
Patient not performed MMS last year	X
Patient not checked with blood tests last 6 months.	X
Lists and sub-populations	
Patients with atrial fibrillation and type of blood thinning treatment	
Patients on metformin and their eGFR values	
List of patients with status "monitored"	
List of all patients and the date of MMS	
List of all patients and the date of Berger dementia scores	
List of all patients and the date of labtesting	
List of all patients and the date of/and their nursing load score	
Patients with active enforcement decisions	
List of all patients who have active alerts and the type of alerts	
All MY patients with event/note last day, 7 days, 30 days, 365 days	
Drug sub-populations	
Patients on: ACEI or A2B	
Patients on: Other antidiabetic agents than insulin	
Patients on: Antibiotics	
Patients on: Antidepressants	
Patients on: Antidiabetics	
Patients on: Antiepileptics	
Patients on: Anti-Parkinson drugs	
Patients on: anxiolytic	
Patients on: Benzodiazepines	
Patients on: Beta-blockers	
Patients on: Dementia Medications	
Patients on: Digitalis	
Patients on: Diuretics	
Patients on: DPP-4 inhibitors	
Patients on: Hypnotic	
Patients on: Insulin	
Patients on: Calcium channel blockers	
Patients on: Warfarin	
Patients on: Neuroleptics	
Patients on: NSAIDs	
Patients on: Opioids	
Patients on: Paracetamol	
Patients on: Thyroid hormone substitusjon	

*An alert pops up within the patients record on due date



Faste rutiner

Tatt ut av Kjell Krüger - 02.08.2012 09:55:15

Oppdatering av påminnelser

Påminnelsene oppdateres vanligvis bare hver gang journalen åpnes. Påminnelsen kan derfor bli "gamle" hvis ikke journalen åpnes jevnlig. Hvis det er mer enn 14 dager siden påminnelsene er oppdatert vil siste kolonne ha rød tekst. Du bør da åpne journalen til disse pasientene og ta ut denne rapporten på nytt.

2A Department	Hulten	Berger	Blodtrykk	Kostsamtale	Vekt	Blodprøver	Oppdatert
Patients	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 21:58
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 09:40
	Hulten er tatt	Berger er tatt	*Gjenta blodtrykk*	Kostsamtale	Nylig veid	Labdata funnet	02.08.12 08:49
	Hulten er tatt	Berger er tatt	*Gjenta blodtrykk*	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 09:39
	Hulten er tatt	*Ta ny Berger*	*Gjenta blodtrykk*	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 09:39
	Hulten er tatt	Berger er tatt	*Gjenta blodtrykk*	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 09:40
	Hulten er tatt	Berger er tatt	*Gjenta blodtrykk*	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 15:00
	Hulten er tatt	Berger er tatt	*Gjenta blodtrykk*	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 09:42

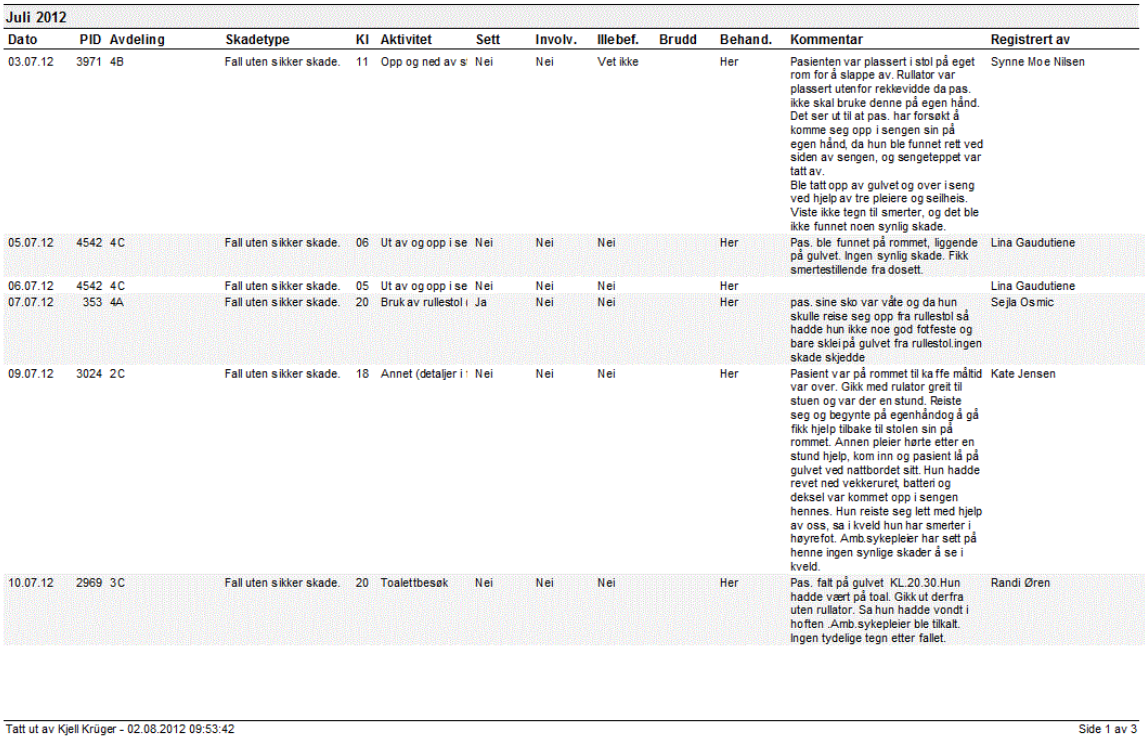
2B Department	Hulten	Berger	Blodtrykk	Kostsamtale	Vekt	Blodprøver	Oppdatert
Patients	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	02.08.12 09:45
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 15:06
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	30.07.12 10:55
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 14:09
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	30.07.12 10:56
	Ta ny Hulten	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 14:14
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 14:09
	Ta ny Hulten	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 15:08

2C Department	Hulten	Berger	Blodtrykk	Kostsamtale	Vekt	Blodprøver	Oppdatert
Patients	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 13:09
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	*Gjenta veiing*	*Labdata mangl*	01.08.12 16:03
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 13:29
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 13:28
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	*Labdata mangl*	01.08.12 13:27
	Ta ny Hulten	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 14:14
	Ta ny Hulten	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	01.08.12 15:06
	Hulten er tatt	Berger er tatt	Nylig målt blodt	Kostsamtale	Nylig veid	Labdata funnet	30.07.12 12:35

Løvåsen Sykehjem

Side 1 av 7

Figure 18. Demonstrates a report which shows how each department complies with a set of routines (e.g. monthly weighing). Missing accomplishments are shown with yellow background.



Juli 2012

Dato	PID	Avdeling	Skadetype	Kl	Aktivitet	Sett	Involv.	Illebef.	Brudd	Behand.	Kommentar	Registrert av
03.07.12	3971	4B	Fall uten sikker skade.	11	Opp og ned av s	Nei	Nei	Vet ikke		Her	Pasienten var plassert i stol på eget rom for å slappe av. Rullator var plassert utenfor rekkevidde da pas. ikke skal bruke denne på egen hånd. Det ser ut til at pas. har forsøkt å komme seg opp i sengen sin på egen hånd, da hun ble funnet rett ved siden av sengen, og sengeteppet var tatt av. Ble tatt opp av gulvet og over i seng ved hjelp av tre pleiere og seilheis. Viste ikke tegn til smerter, og det ble ikke funnet noen synlig skade.	Synne Moe Nilsen
05.07.12	4542	4C	Fall uten sikker skade.	06	Ut av og opp i se	Nei	Nei	Nei		Her	Pas. ble funnet på rommet, liggende på gulvet. Ingen synlig skade. Fikk smertestillende fra dosett.	Lina Gaudutiene
06.07.12	4542	4C	Fall uten sikker skade.	05	Ut av og opp i se	Nei	Nei	Nei		Her		Lina Gaudutiene
07.07.12	353	4A	Fall uten sikker skade.	20	Bruk av rullestol i	Ja	Nei	Nei		Her	pas. sine sko var våte og da hun skulle reise seg opp fra rullestol så hadde hun ikke noe god fotfeste og bare skled på gulvet fra rullestol.ingen skade skjedde	Sejla Osmic
09.07.12	3024	2C	Fall uten sikker skade.	18	Annet (detaljer i	Nei	Nei	Nei		Her	Pasient var på rommet til kaffe måltid var over. Gikk med rulator greit til stuen og var der en stund. Reiste seg og begynte på egenhåndog å gå fikk hjelp tilbake til stolen sin på rommet. Annen pleier hørte etter en stund hjelp, kom inn og pasient lå på gulvet ved nattbordet sitt. Hun hadde revet ned vekkeruret, batteri og deksel var kommet opp i sengen hennes. Hun reiste seg lett med hjelp av oss, sa i kveld hun har smerter i høyrefot. Amb.sykepleier har sett på henne ingen synlige skader å se i kveld.	Kate Jensen
10.07.12	2969	3C	Fall uten sikker skade.	20	Toalettbesøk	Nei	Nei	Nei		Her	Pas. falt på gulvet KL.20.30.Hun hadde vært på toal. Gikk ut derfra uten rullator. Sa hun hadde vondt i hoften .Amb.sykepleier ble tilkalt. Ingen tydelige tegn etter fallet.	Randi Øren

Tatt ut av Kjell Krüger - 02.08.2012 09:53:42

Side 1 av 3

Figure 19. Demonstrates a monthly report of all injuries recorded.

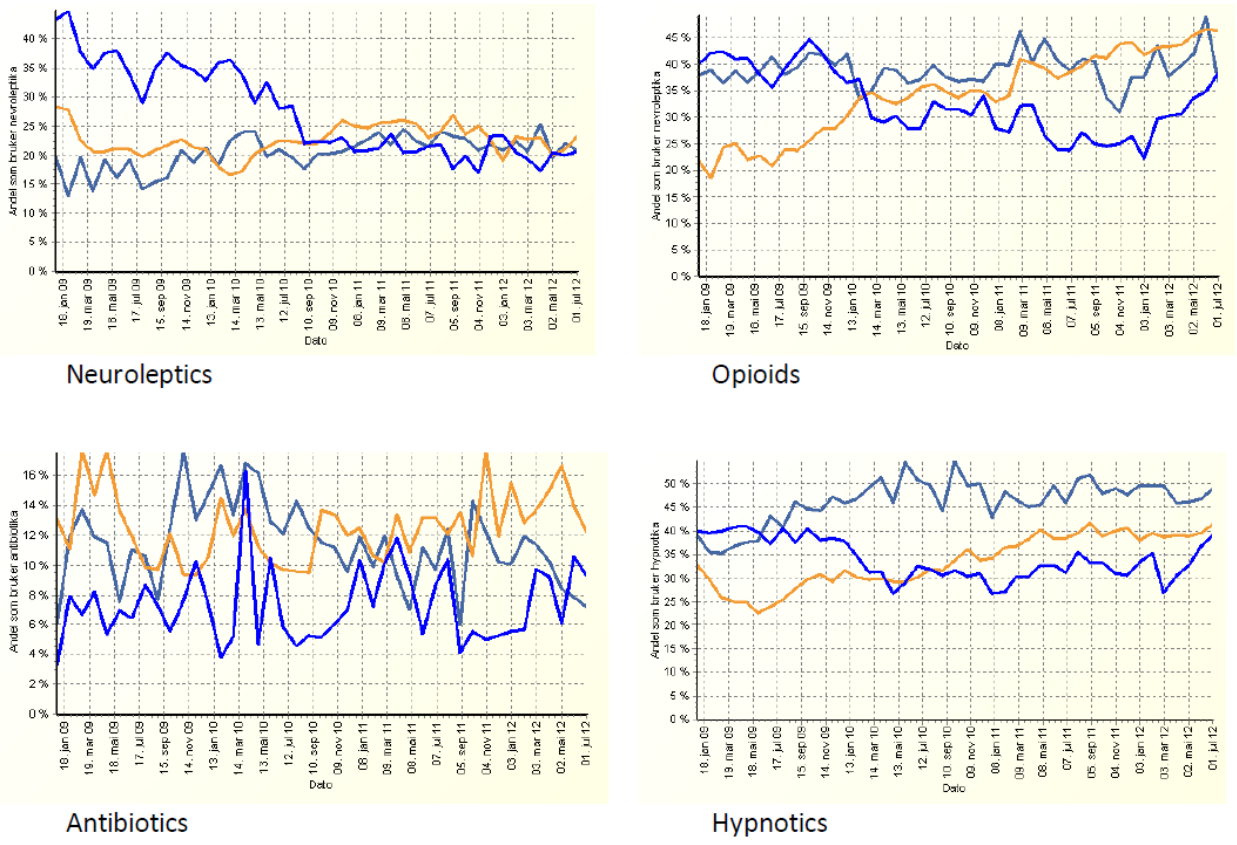


Figure 20. The screen-shot above shows timeline-curves which are comparing the use of 4 different drug groups at 3 institutions (percentage patients on drug) in Bergen, Norway.

Research update

An important study with relevance to our work has been performed at Sankt Olav´s Hospital in Trondheim and Ullevål Hospital in Oslo, Norway, during the last year. The authors "performed an observational study of consecutive unplanned inpatient admissions using a structured form to register a set of predefined parameters and free-text notes, including a post-examination interview with the examining emergency department doctors and nurses. They observed 177 patient admissions, excluding any patients under 18 years of age and planned admissions. Out of those admitted 68% were living at home with an additional 16% living at home, but enrolled in community home care services. 5% were transferred from institutional community care and 6% were transferred from other hospitals or specialist outpatient clinics" [153]. 5 percent hospital admissions from nursing homes confirm the findings in our study. This is important as it confirms that our nursing home materials in Bergen are similar to other nursing home populations in Norway and thus strengthens the validity of our findings.

Another work on hospitalizations from nursing homes in Bergen has been published the last year. The acute hospitalizations of the nursing home residents were identified through ambulance records (same method as we had used, but a year later). These were linked to hospital patient records for inclusion of demographics, diagnosis at discharge, length of stay and mortality. Incidence of hospitalization was calculated based on patient-time at risk.

"The annual hospital admission incidence was 0.62 admissions per person-year among the nursing home residents and 0.26 among the community dwellers. In the nursing home population the dominant diagnoses were respiratory diseases, falls-related and circulatory diseases, accounting for 55% of the cases". The median length of stay was 3 days (interquartile range = 4). The in-hospital mortality rate was 16% and 30 day mortality after discharge 30%. Acute hospital admission rate among nursing home residents was high in this Scandinavian setting. The pattern of diagnoses causing the admissions appears to be consistent with previous research. The in-hospital and 30 day mortality rates are high compared to international studies [154]. Also this study confirms our findings a few years earlier, especially with regard to diagnostic reasons for hospitalizations from nursing homes. We assume this may be similar in Norway as such, even though we must bear in mind that the figures apply to populations with university hospitals as primary hospital.

Performing a PUBMED search on the phrase "electronic decision support" (publication title) gives 22 publications from 2012 [155-176]. They all proved more or less positive results.

A few studies have been performed since 2005 on drug use among elderly and nursing home patients. Methods for reducing drug related problems have been subject to a meta-analysis, but results are non-decisive [177]. SSRIs have been withdrawn from nursing home residents in Sweden, often successfully [178]. On the other hand psychiatric and behavioral symptoms are frequent in nursing homes and the rate increases with the progression of the dementia, so systematic programs are needed for disseminating skills and providing guidance regarding the evaluation and treatment of these symptoms in nursing homes [179].

A recent study confirmed the prevalence findings from our own study. They examined trends in psychotropic drug prescribing in Norwegian nursing homes from 1997 to 2009, in order to gain insight in practice development. Prevalence of all psychotropic drugs combined increased from 57.6% to 70.5%, anxiolytics from 14.9% to 21.9%, hypnotics from 14.5% to 22.9%, and antidepressants from 31.5% to 50.9%. Prevalence of antipsychotics varied between extremes 21.1% and 25.6% [180].

Recent randomized clinical trials of novel anticoagulants, including direct thrombin inhibitors and factor Xa inhibitors, have demonstrated non inferiority and superiority over warfarin for stroke prevention. They are also safer and do not require laboratory monitoring. These novel anticoagulants have the potential to replace vitamin K antagonists and even aspirin in preventing AF-related stroke. Results are probably still pending for the oldest population and the price compared to warfarin may be an issue in nursing homes. The bleeding profile is however promising [181-187]. A broad update on this issue is also discussed in a panel of specialists in October 2011 on MedScape: **Evolving Philosophies: Stroke Prevention in Atrial Fibrillation A Review of Recent Clinical Trial,** (http://www.medscape.org/viewarticle/750011?src=0_mp_cmenl_0).

Several new studies have been performed which further strengthen ProBNP as a diagnostic tool and monitoring tool of heart failure, also in elderly patients. The identified risk by elevated ProBNP, whether it's a risk for death or a risk for heart failure hospitalization, lower values are better, higher values are worse. There's no question about that. But what we also know, based on the data from Val-HeFT, is that while a single measurement is useful, serial measurements seem to inform even better prognostic value [119-121]. This also refers to patients above 75. A panel of experts has discussed these issues at MedScape newly: **Guiding Heart Failure Therapy: An Update on the Role of Biomarkers**, (http://www.medscape.org/viewarticle/743110?src=0_mp_cmenl_0).

Performing a PubMed search (Abstract contains "Structured electronic medical records" or any field contains "structured EPR" or any field contains "structured EMR" and year contains "2012") reveals 67 articles of which only 15 is considered relevant to this thesis [166, 188-201]. All in all the review confirms the impression of our and earlier research which shows positive results of structuring clinical information, however not forgetting the cautions mentioned earlier.

When it comes to the issues of guideline adherence, quality of drug prescriptions among elderly and need for quality improvement methods, several studies the last years confirm the views presented in this thesis [202 - 215].

Conclusions

Conclusion on primary objectives

A 12 months intervention with the tested structured electronic medical record system and the selected alarms and population lists reduced proportion patients not weighed last 30 days, seemed to increase the proportion patients with atrial fibrillation getting warfarin and reducing the proportion patients using neuroleptics. All improvements were significant in our study, but material was too small for firm conclusions.

Conclusions on secondary objectives

There are research results available to show that structured electronic patient records can produce faster data recording, higher quality, and notes that are satisfactory for day-to-day clinical use. Concerns about unforeseen consequences however also exist.

The structured electronic patient record system with decision support we tested can easily be installed for use in nursing homes and user satisfaction is high. Controlled studies on a broader specter of clinical and administrative parameters should be performed.

Monitoring diagnoses and admission rates to hospitals from nursing homes can give a sound basis for evaluating different aspects of running nursing homes. To record “nursing home patient” in the hospital electronic medical record at admission would enlighten research. Optimal treatment of pneumonias in nursing homes may play a role to reduce pressure on medical departments. Solely increasing physician coverage in nursing homes will probably not reduce the number of hospitalizations.

There are differences in treatment with psychoactive drugs between nursing homes. Treatment differences also exist between patients with/without cognitive impairment but reasons remains unclear. Improvement strategies and more research are needed. The proportion of patients per institution on selected drugs can serve as a feedback parameter in quality systems but adding DDDs increases differences.

Long-term patients with atrial fibrillation and heart failure in nursing homes are treated inadequately and/or dissimilarly. Strategies are needed to improve quality of cardiovascular treatments. Data on patient consequences of these differences are not present. Recording the irregular patient pulse by nurses and doctors and measuring ProBNP regularly may improve this. ProBNP levels in nursing home patients are probably not seriously biased by patient weight, age and renal function at levels above 225 pmol/l.

A theoretical possibility exists that structured medical records may produce valid quality and production parameters which has been lacking in NPM administration of healthcare.

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Appendix

Approvals

Krüger. Kjell

Fra: Arne Kristian Salbu [Arne.Salbu@medfa.uib.no]
Sendt: 13. oktober 2006 14:42
Til: Krüger, Kjell
Emne: RE: Utvikling av strukturert journalsystem på sykehjem

REK Vest v/leder, professor Jon Lekven og undertegnede har vurdert spørsmålet om fremleggingspilikt for det skisserte opplegget.

Vi har kommet frem til at uttesting av dette journalsystemet ikke er å anse som forskning på mennesker og at det derfor kan gjennomføres uten at saken trenger bli vurdert av REK på forhånd.

Vennlig hilsen

Arne Salbu
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From: Krüger, Kjell [mailto:Kjell.Krueger@bergen.kommune.no]
Sent: Monday, October 02, 2006 2:13 PM
To: Arne Kristian Salbu
Subject: Utvikling av strukturert journalsystem på sykehjem

REK-3
Universitetet i Bergen, Det medisinske fakultet, Postboks 7804, 5020 Bergen

Att.: Sekretær Arne Salbu

Fyllingsdalen 021006

Informasjon om Prosjektet "Geriatrisk Basis Datasett for sykehjemspasienter - utvikling, implementering og evaluering"

-----Opprinnelig melding-----
Fra: Christine Ask Ottesen [mailto:christine.ask.ottesen@datatilsynet.no]
Sendt: 30. oktober 2006 17:09
Til: Krüger, Kjell
Emne: SV: Geriatrisk Basis Datasett i Bergen

Hei,

Etter Datatilsynets vurdering vil implementering og bruk av Geriatrisk Basis Datasett ikke være en behandling det er nødvendig å søke konsesjon for. Slik Datatilsynet forstår den oversendte informasjonen vil systemet være et journalsystem på lik linje med øvrige. Prosjektet vil således ikke falle innenfor kategorien forskning. At det er behov for å opprettholde det "gamle" journalsystemet i en overgangsfase vil heller ikke være avgjørende.

Dette forutsetter selvsagt at opplysningene ikke benyttes på annen måte enn ved normal bruk av journalsystem og at sikkerheten og tilgangsstyringen fungerer tilfredsstillende.

Datatilsynet anbefaler at KITH involveres i prosessen. Tilsynet ønsker videre å presisere at det ikke vil være grunnlag for dobbel journalføring etter at prøveperioden er gjennomført.

Vennlig hilsen
Christine Ask Ottesen

Publications

1. Krüger K, Jansen K, Grimsmo A, Eide G E, Geitung J T. "Hospital admissions from Nursing Homes: Rates and Reasons". Nursing Research and Practice. Volume 2011, Article ID 247623, 6 pages.
2. Krüger K, Folkestad M, Geitung J T, Eide G E, Grimsmo A. "Psychoactive drugs in seven nursing homes". Primary Health Care Research & Development. 2012; 13 (3); 244-254.
3. Krüger K, Sandli M, Grimsmo A, Eide G E, Geitung J T. "Atrial fibrillation and heart failure in seven nursing homes". Journal of Nursing Education and Practice. 2012; 2(4); 22-32.
4. Krüger K, Strand L, Geitung J T, Eide G E, Grimsmo A. "Can Electronic Tools Help Improve Nursing Home Quality?" ISRN Nursing. Volume 2011, Article ID 208142, 8 pages.

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Research Article

Hospital Admissions from Nursing Homes: Rates and Reasons

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Hospital admissions from nursing homes have not previously been investigated in Norway. During 12 months all hospital admissions (acute and elective) from 32 nursing homes in Bergen were recorded via the Norwegian ambulance register. The principal diagnosis made during the stay, length of stay, and the ward were sourced from the hospital's data register and data were merged. Altogether 1,311 hospital admissions were recorded during the 12 months. Admissions from nursing homes made up 6.1% of the total number of admissions to medical wards, while for surgical wards they made up 3.8%. Infections, fractures, cardiovascular and gastri-related diagnoses represented the most frequent admission diagnoses. Infections accounted for 25.0% of admissions, including 51.0% pneumonias. Of all the admissions, fractures were the cause in 10.2%. Of all fractures, hip fractures represented 71.7. The admission rate increased as the proportion of short-term beds increased, and at nursing homes with short-term beds, admissions increased with increasing physician coverage. Potential reductions in hospitalizations for infections from nursing homes may play a role to reduce pressure on medical departments as may fracture prevention. Solely increasing physician coverage in nursing homes will probably not reduce the number of hospitalizations.

1. Background

It is expected that nursing homes will play an important role in health care delivery in the years ahead. The population is growing older, and the patients admitted to hospitals are being discharged earlier. A Norwegian white paper states that reform is needed to the collaboration between primary care and hospitals [1]. The growth in costs and utilization of hospitals is not sustainable. Among several proposals, the white paper points to accomplishments involving early discharges from hospitals to nursing homes, which offer structured rehabilitation programmes. Evaluations have shown a reduction in mortality, readmission, and later need for home care for elderly patients [2]. Palliative units in nursing homes have also been a success [3].

On the other hand, little research has been done on admissions from nursing home to hospital. There are no studies in this field from Norway [4]. Internationally, a correlation has been found between the lack of documented decisions on the level of treatment and the increase in admission rate [5]. Clear documentation in logs and records concerning hospital admissions and heart-lung do-not-resuscitate decisions can prevent unnecessary admissions. Acknowledged routines currently in place to treat terminal patients (Liverpool Care Pathway) may be important to make these decisions easier in nursing homes [6]. We also know that information gaps commonly occur when elderly patients are transferred from a nursing home or seniors' residence to the hospital [7].

Norway has 4.6 million inhabitants, 55 public hospitals, 41,052 nursing home beds, and 1,796 beds in old people's homes, 96.8% of nursing home beds are in single rooms, and 43,3% of all deaths (total 41,342) are in nursing institutions [8]. The healthcare system is split in first- and second-line services. The second line contains the 55 hospitals and specialist services (included private specialists). Second

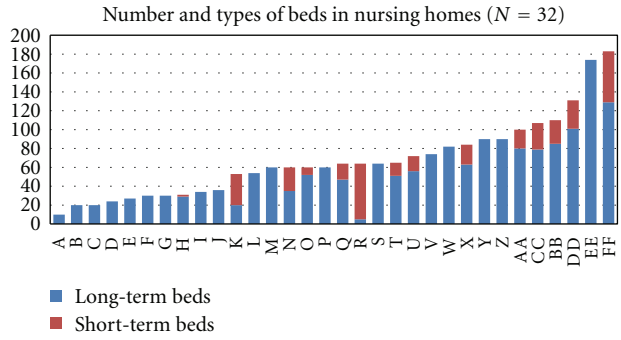


Figure 1: Size and proportion of long-term and short-term beds in all 32 nursing homes in the city of Bergen (250 000 inhabitants), Norway. The red part indicates short-term beds (3-4 weeks stays) and the blue part long-term beds (permanent stays).

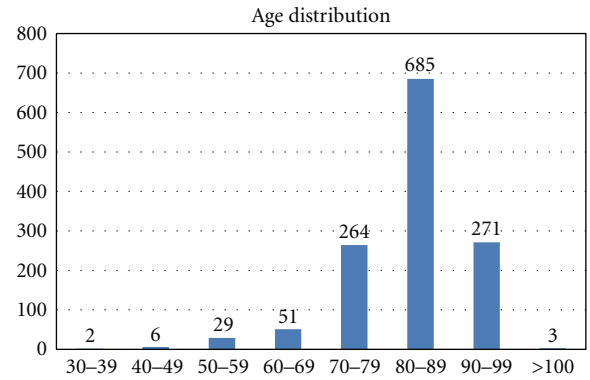


Figure 2: Age distribution of patients admitted to hospital from nursing homes in the city of Bergen, Norway, during the period from March 2006 to March 2007 ($N = 1311$).

line is administered and financed directly from the state. First-line services are administered and financed by the municipalities ($N = 431$). First line covers general practice (GP) services, mother and child care, home care, and nursing homes ($N = 900$).

The study was approved by the Norwegian Social Science Data Services.

This study investigates the incidence of hospitalizations from nursing homes, the major diagnostic reasons, what burden these hospitalizations represent for the main hospital departments, and what impact manpower and short- to long-term bed ratio have.

2. Materials and Method

In 2007, the Norwegian city of Bergen had approximately 250,000 inhabitants and in total 32 nursing homes (2,300 beds, including 300 short-term beds), see Figure 1. Long-term beds are for permanent residents, mostly until their death. Short-term beds are mainly for 3-4 weeks rehabilitation stays after hospitalization. In nursing homes in Bergen, about 50% of physician services are performed by doctors in permanent positions and the rest by GPs in part-time positions.

During the period from March 2006 to March 2007 (12 months), all hospital inpatient admissions from nursing homes in the Municipality of Bergen to the primary and referral hospital were recorded (the two only hospitals in Bergen). This was done by searching the ambulance service's register of transports from nursing home addresses to the two hospitals. These patient transports were then compared with the hospitals' case history registers to find ward, diagnoses (ICD-10), and length of stay. The ambulance register was the only complete source to find fairly complete figures on hospitalizations from nursing homes for this retrospective study. To search more information about each patient from the hospital records was beyond the scope of the study. Calculations are based on the principal diagnosis. Information about physician manpower, number of total beds and number of short-term beds was gathered from the county health administration.

Two hospitals are delivering hospital services to the city and surrounding municipalities. Bergen population represents 62.5% of the total population served by the hospitals (population 400 000).

There is only one, public, ambulance service in Bergen. Close to 100 percent of admissions from nursing homes to the hospitals are made by means of ambulance. All transports, patient name, transport addresses, and key medical observations are registered in a database.

Linear regression analysis was used to relate admission rates for the nursing homes to the proportion of short-term beds and the proportion of explained variation in admission rates expressed by the determination coefficient (R^2). For analyzing data, we used Excel and JMP 8.

3. Results

Altogether, 1,311 hospital admissions were recorded during the 12 months. We found a primary diagnosis in 1185 of the cases. The number of admissions was 800 (61.0%) to medical wards (ex pulmonary ward), 385 (29.4%) to surgical wards, 58 (4.4%) to the pulmonary ward, 39 (3.0%) to the neurological ward, and 29 to other wards (2.2%).

The age distribution is shown in Figure 2. 959 (73.2%) patients were at least 80 years of age. Total number of age-specific hospital bed days compared to hospital bed days among nursing home patients is presented in Table 1. Age specific hospitalization rates for total Norway compared to rates among nursing home patients is presented in Figure 3. The diagnoses from hospital stays are presented in Table 2 for the medical and surgical wards. Infections, fractures, and gastrointestinal and cardiac diagnoses stood out as the most frequent reasons for admissions.

The average length of stay was 4.3 days. There was no significant difference between the average length of stay on medical and surgical wards. A total of 497 (38.0%) of the admissions had a duration of only one inpatient day.

Table 1: Total number of age-specific hospital bed days (all departments and all diagnoses) in the Western Health Region of Norway as compared to hospital bed days among nursing home patients.

Age groups	Bed days in hospital per 1000
0–15 years	401.90
16–49 years	383.33
50–66 years	898.16
67–79 years	2427.20
80 years and above	4322.56
All ages	816.83
Nursing home patients within hospitals' responsibility regions.	3531.30

(Source: Statistics Norway).

Table 2: The generic groups for admissions to medical and surgical wards from nursing homes in the city of Bergen, Norway, from March 2006 to March 2007 ($N = 1185$ with diagnosis).

	Medical ward	Surgical ward	Total	As % of admissions ($N = 1185$)
Fractures	9	125	134	11.31
Gastric	91	42	133	11.22
Cardiac	121	2	123	10.38
Infections	267	34	301	25.40
Pulmonary	59	0	59	4.98
Nephrological	23	10	33	2.78
Neurological	69	1	70	5.91
Tumour/cancer	21	27	48	4.05
Urinary tracts	3	66	69	5.82
Other	138	78	215	18.22
Total	801	385	1185	100

Of all the admissions (1,311), infection diagnoses represented 328 (25.0%). Pneumonias and suspected pneumonias represented 51.0% of infections and 12.8% of all admissions, Figure 4. The incidence of hospitalizations caused by infection was 138/1,000 nursing home beds per year.

Fractures were the second most frequent cause counting 134 (10.2%) admissions. Institutions with high fracture rate could have low infection rate and vice versa. The types of fracture are as described in Figure 5. Hip fractures represented 94 (71.7%) of fractures and were the commonest. After excluding the smallest institutions (less than 30 beds) due to probable patient differences, we found a variation in fracture incidence from 0 to 16/100 patient years, the average being 6.4. Only one institution had no fractures. The incidence of fractures treated in hospital among the total population was 5.6/100 patient years during the 12 months under review.

The total number of admissions to medical wards in the two actual hospitals is approximately 21,000 a year, while to surgical wards it is 16,000 admissions [9]. Bergen city

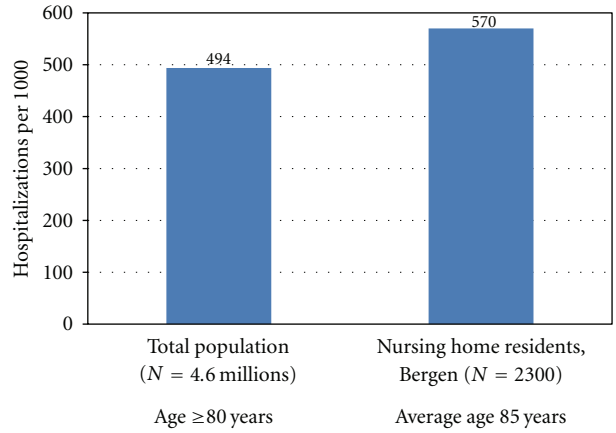


Figure 3: Hospitalization rates (per 1000 inhabitants/residents) for total Norway ($N = 4.6$ millions, age ≥80 years) and among nursing home patients ($N = 2300$, long- and short-term, average age appr. 85 years), 2007, in Bergen, Norway. (Source: Statistics Norway).

represents 62.5% of the total hospital responsibilities. The 800 admissions from nursing homes to the medical wards thus made up 3.8% (6.1% assuming the hospitalization rates from other municipalities had a similar rate) of the total number of admissions. This represented 3440 (5508) bed days calculated on the basis of the average length of stay. For surgical wards the admissions counted for 2.4% (3.8%) and 1656 (2614) bed-days.

Number of beds in the nursing homes ranged from 20 to 189. 17 institutions had only long-term beds. The percentage of short-term beds among the 15 mixed homes (long- and short-term beds) ranged from 7% to 92%. Physician manpower ranged from 0.16 to 2.12 hours per bed per week. Linear regression analysis showed a significantly higher admission rate for nursing homes with a high proportion of short-term beds than those with a low proportion ($R^2 = 0.55$, $P = .0016$) and also a tendency to higher admission rates as a result of increased physician manpower, see Figure 6. Average physician coverage was 0.48 hours per bed per week, which significantly positively correlated with the percentage of institutional short-term beds.

4. Discussion

The incidence of hospitalizations from nursing homes was 570 per 1000 nursing home beds per year. Hospitalizations (age specific) from nursing homes were less than from the general population. Admissions from nursing homes made up 6.1% of the total number of admissions to medical wards while for surgical wards they made up 3.8%. Infections, fractures, cardiovascular and gastri-related diagnoses represented the most frequent admission diagnoses. Infections accounted for 25.0% of admissions, including 51.0% pneumonias. Of all the admissions, fractures were the cause in 10.2%. Of all fractures, hip fractures represented 71.7%. The admission rate increased as the proportion of

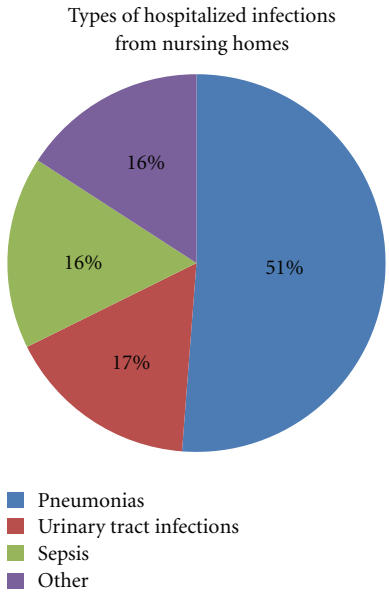


Figure 4: Types of infections on admission from nursing home to hospital in Bergen, Norway, during the period from March 2006 to March 2007 ($N = 328$).

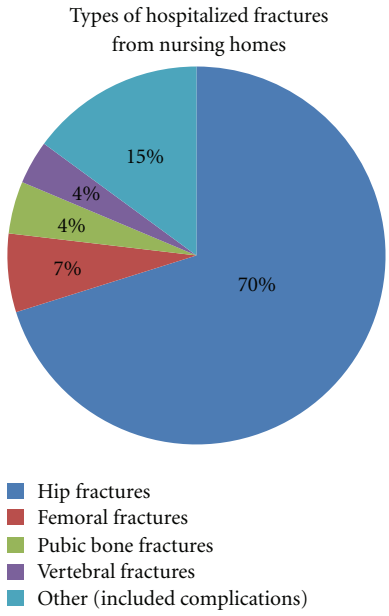


Figure 5: Types of fractures on admission from nursing home to hospital in Bergen, Norway, during the period from March 2006 to March 2007 ($N = 134$).

short-term beds increased, and at nursing homes with short-term beds, admissions increased with increasing physician coverage.

5. Limitations of the Study

The role of nursing homes in the delivery of social and health care services differs between, as well as within, countries. Nursing homes in many countries are managed as a part of social care. In Norway nursing homes are regulated as a health care service. These differences may influence the health issue landscape and the composition of staff. Thus, comparisons and generalizations based on our findings should be done with care.

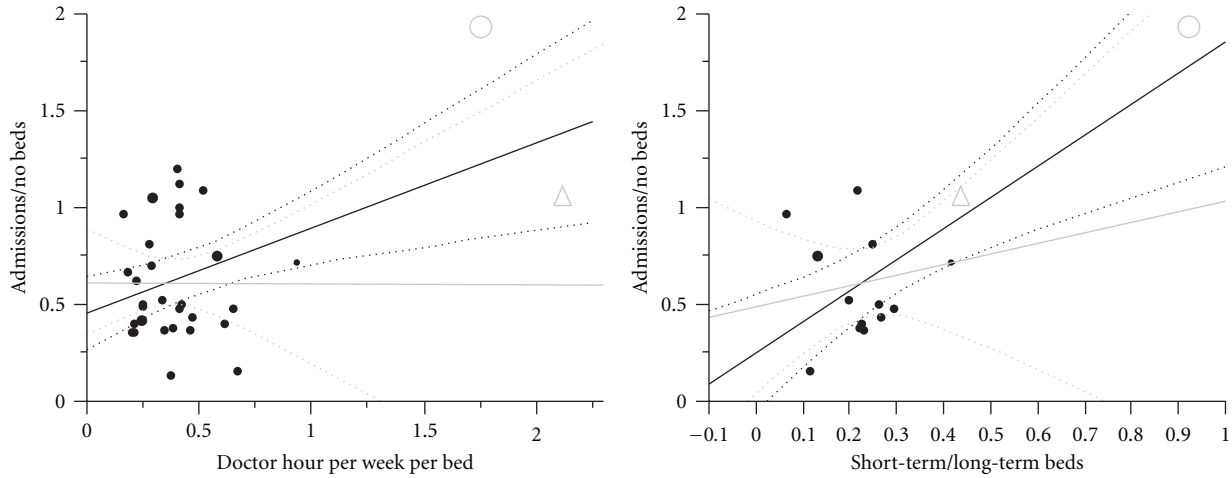
We estimated that close to 100% of the admissions from nursing homes take place using the ambulance service and therefore considered the basic material reliable. However, it contains no information about the degree of general debilitation or the degree of dementia. This is a weakness. It is difficult to decide whether or not the admissions were unnecessary. The material is too superficial for that. An indication of comorbidity is given by numbers of secondary diagnosis, which range from 0 to 9, averaging 2.9. Our project had access only to anonymous data and could not count readmissions, therefore. This strengthens the material from a patient and data security perspective but calls for further research.

6. Reasons for Admissions to Hospital

All have the same right to proper medical treatment in hospitals independent of age. For some old and fragile patients in nursing homes, however, being hospitalized may represent a burden [4]. Both from a patient and society perspective, it may be worth examining ways to reduce hospitalizations for some nursing home patients.

It has previously been shown that infections are the most common causes of hospital admissions from nursing homes [10–12]. This is confirmed by our results. Most frequent infections in nursing homes have been urinary tract infections (28–41%), respiratory tract infections (25–32%), and skin/soft tissue infections (17–19%) [10, 13–16]. Among hospital admissions we found that urinary tract infections account for 16.5% of infections and pneumonias for 51.2%. One measure that may reduce infection admissions is to ensure that current knowledge about vaccination against influenza and pneumococcal infection is put into practice. Modern nursing homes with small wards may reduce the infection rate of contagious infections, but we found no studies where the impact of these measures on hospitalization rates from nursing home residents has been tested. To reduce hospitalizations due to infections, it is important to secure qualified staff and necessary equipment in nursing homes. Intravenous drug and fluid treatment is needed. Mobile X-ray units can serve several municipalities/nursing homes [17].

Two studies showed that hip fractures had an incidence rate of 3.1% per year among nursing home residents with an average age of 85 [18, 19]. We found a yearly rate of 4.0% but with considerable differences among nursing homes. With regard to measures to prevent fractures, we know that the potential benefit of hip protectors in reducing hip fractures in nursing home residents requires further confirmation [20, 21]. So far Vitamin D supplement seems to give some fracture protection [22]. The great variation in admissions for hip fractures among the institutions,



(a) (b)

Figure 6: (a) Admissions correlated to physician hours per bed per week ($N = 32, R^2 = 0.24, P = .0041, y = 0.4396x+0.4549$), grey line with two institutions with high number of short-term beds and extra staffing excluded. (b) Admissions correlated to short-term/long-term beds. Institutions with zero short-term beds excluded from analysis. Grey line with one institution with almost only short-term beds excluded. ($N = 15, R^2 = 0.55/0.04, P = .0016/0.51, y = 1.6074x + 0.2488$ for grey line). Dotted lines are confidence curves for regression lines. The grey circle represents institution 32 (92% short-term beds), and the grey triangle represents institution 31 (43% short-term beds).

including institutions of comparable size and manpower, should be examined in more detail. This may provide more knowledge about fracture prevention and differences in hospitalization practice. More differentiation in the use of psychoactive drugs for patients at risk of falling could prove valuable like patients with/without the ability to walk unaided.

7. The Influence of Manpower

Varying results exist as to the impact the number of nurses has on the frequency of hospital admissions [13, 23, 24]. A retrospective study of 6,623 nursing home patients found that increasing the proportion of nurses cuts the number of short-term patient readmissions, but there was no difference for long-term patients [25]. This seems logical as more manpower makes more advanced treatment possible.

We found a correlation in the number of admissions from increased physician manpower, with the exception of admissions due to fractures. The need for hospitalization for fractures is probably obvious for all types of health personnel, while many other diagnoses are dependent on diagnostics done by a physician. For example, a study found an increase in the incidence of infections associated with increased physician coverage [24]. An increase in physician manpower in nursing homes might thus have two differentiated effects and be dependent on the composition of diagnoses and the level of diagnostics at the outset. The admission rate will increase for problems better suited to hospitalization and decrease for problems best treated by physicians in the nursing home. Our finding, then, that a higher level of physician manpower was associated with an increased number of admissions may indicate general understaffing of physicians in nursing homes. That increasing proportions of short-term beds leads to increased number of admissions correlates to our expectations. Short-term patients are often still in active treatment relationships with hospital departments and thus probably more frequent readmissions.

55 peer-reviewed articles on interventions that can potentially reduce hospitalizations from formal long-term care settings show the strongest potential for increasing skilled staffing, especially through physician assistants and nurse practitioners [26].

8. Conclusions

Monitoring diagnoses and admission rates to hospitals from nursing homes can give a sound basis for evaluating different aspects of running nursing homes. To record "nursing home patient" in the hospital electronic medical record at admission would enlighten research. Optimal treatment of pneumonias in nursing homes may play a role to reduce pressure on medical departments. Solely increasing physician coverage in nursing homes will probably not reduce the number of hospitalizations.

Conflict of Interests

The authors declare no conflict of interests.

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RESEARCH

Psychoactive drugs in seven nursing homes

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Aims: We wanted to pinpoint any differences in treatment between participating nursing homes, investigate which drugs are currently prescribed most frequently for long-term patients in nursing homes, estimate prevalence of administration for the following drug groups: neuroleptics, antidepressants, antidementia agents, opioids and the neuroleptics/anti-Parkinson's drug combination, and study comorbidity correlations. We also wanted to study differences in the administration of medications to patients with reduced cognitive functions in relation to those with normal cognition. **Methods:** Information about 513 patients was collected from seven nursing homes in the city of Bergen, Norway, during the period March–April 2008. This consisted of copying personal medication records, weighing, recording the previous weight from records, electrocardiography, anamnestic particulars of any stroke suffered, recording if there is cognitive impairment or not and analyzing a standardized set of blood samples. **Results:** Considerable treatment differences existed between nursing homes, both percentage patients and Defined Daily Dosages. Patients with reduced cognitive functions were prescribed less drugs in general, except neuroleptics. Of all patients, 41.5% were given antidepressants, 24.4% neuroleptics, 22.0% benzodiazepines, 8.0% anticholinesterases and 5.0% memantine. The ratio of traditional to atypical neuroleptics was 122:23. In all, 30.0% of the patients taking neuroleptics were on more than one drug and 35.0% of the patients had opioids by way of regular or as-needed drugs, ratio 14.6%:28.7%. Of 146 patients on neuroleptics, five patients had anti-Parkinson's drugs too. The average use of regular drugs for patient with intact cognition was 7.1 drugs, and for patients with reduced cognitive functions 5.7 drugs. **Conclusions:** There are differences in treatment with psychoactive drugs between nursing homes. Patients with reduced cognitive functions receive less cardiovascular drugs than patients with normal cognition. The reason for this still remains unclear. Improvement strategies are needed. The proportion of patients per institution on selected drugs can serve as a feedback parameter in quality systems.

Key words: drug safety; health care quality assessment; health care quality indicators; management quality circle; nursing homes; pharmacoepidemiology

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Background

Norway has 4.6 million inhabitants, 55 public hospitals, 41 052 nursing home beds and 1796 beds in old people's homes, 96.8% of nursing home beds are in single rooms and 43.3% of all deaths (total 41 342) are in nursing institutions (Statistics Norway, 2010). The health care system is split in first- and second-line services. The second line contains the 55 hospitals and specialist services (included private specialists). Second line is administered and financed directly from the state. First-line services are administered and financed by the municipalities ($n = 431$). First line covers general practice services, mother and child care, home care and nursing homes ($n = 900$).

The high consumption of psychopharmaceuticals in nursing homes has been emphasized in a number of studies and the prevalence of psychoactive drugs has been well documented earlier, but some years ago (Ruths *et al*., 2001; Ranhoff and Brors, 2005; Selbaek *et al*., 2008). Few authors have placed the emphasis on treatment differences between nursing homes and the general differences in medication of patients suffering dementia as opposed to non-demented nursing home patients (Nygaard *et al*., 2003).

The high drug consumption among elderly people over 65 is problematic. On average, the elderly nursing home residents in Bergen had five drugs each some years ago (Nygaard *et al*., 2003). In a study of drug consumption at five smallish nursing homes in Norway, drug consumption was found to be greatest within drugs for 'digestive organs and metabolism', 'blood and blood-forming organs', 'heart and circulation', 'urogenital system and sex hormones' and 'nervous system' (Nygaard, 2001).

Polypharmacy has usually been defined as the use of five or more drugs (Hunskår, 2003). Polypharmacy is the most important risk factor for drug side effects and increases the risk of drug interactions (Fastbom, 2001; Johnell and Klarin, 2007).

The elderly are particularly vulnerable to the side effects of psychopharmaceuticals, and anticholinergic burden involves a risk of delirium (Turnheim, 2000). Use of long-acting benzodiazepines can be one of the causes of falls in patients over 65 years of age (Blain *et al*., 2000). Concurrent use of three or more psychopharmaceuticals has been found to be associated with the risk of falling (Gales and Menard, 1995).

In the BEDNURS (The Bergen district nursing home) study, 23% of the patients suffering from dementia, nursing home population in Bergen, Norway, were found to be on antipsychotics (Ruths *et al*., 2001). Double-blind studies have shown little symptom reduction connected with the use of antipsychotics as compared with placebo (Druckenbrod *et al*., 1993; Jeste *et al*., 2008). Of 27 patients, 23 fare well or better without antipsychotics (Ruths *et al*., 2001). In particular, conventional antipsychotics are associated with extra pyramidal side effects, like drug-induced Parkinsonism (Tison *et al*., 1999; Saltz *et al*., 2000). Both atypical and conventional antipsychotics are associated with a significantly greater mortality risk than placebo. The greatest increase in mortality occurred among people taking higher (above median) doses of conventional antipsychotic medications (Wang *et al*., 2005).

We wanted to pinpoint any differences in treatment between participating nursing homes, investigate which drugs are currently prescribed most frequently for long-term patients in nursing homes, estimate prevalence of administration for the following drug groups: neuroleptics, antidepressants, antidementia agents, opioids and the neuroleptics/anti-Parkinson's drug combination, and study comorbidity correlations. We also wanted to study differences in the administration of medication for patients with reduced cognitive functions in relation to patients with normal cognition.

The study was approved by the Regional Ethics Committee of Western Norway.

Methods

Bergen has $\sim 250\,000$ inhabitants and 37 nursing homes (2300 beds). Bed numbers range from 20 to 189. Seven nursing homes participated in this study. Participating nursing homes were selected on the basis of a relative similarity of functions, county ownership (no private institutions) and physician staffing. Nursing home characteristics are presented in Table 1. Only long-term patients ($n = 513$) were included. Sufficient information was available for all patients and they were all included in the analyses.

Information about the patients was gathered during the period between March and April 2008.

Twenty-four medical students conducted the data collection, which consisted of copying medication cards (information about drug names, if regular or as-needed, prescription and dosage), weighing, details of any stroke suffered and degree of cognitive impairment. Electrocardiography was conducted to diagnose atrial fibrillation and a standardized set of blood samples was analyzed.

In order to group the material into patients with/without cognitive impairment, we used the Berger scale (Berger, 1980) and recorded patient information. A caregiver who knew the patient decided between six 'level descriptions' of cognitive impairment, thus rating the degree of severity as a score from 0 to 6. The method was validated by comparing the extent to which drugs for dementia were given to patients scoring above 0, giving a 95% overlap.

The recorded data were keyed into Excel and the drugs were coded according to the Anatomical Therapeutic Chemical (ATC) Drug Register (Skrbo *et al*., 2004). For each drug, the students punched in the full ATC code, dosage, number of times per day given, total daily dosage and whether regular/as-needed. For the psychoactive drugs, which are part of the comparison between institutions, Defined Daily Dosages (DDDs) were registered (except for opioids being part of codine–paracetamol combination drugs). To compare the total use of psychoactive drugs (hypnotics, anxiolytics, antidementia drugs, neuroleptics and opioids) between institutions, we used the calculated parameter: [(Drug DDD) × (% of patients in institution on drugs of drug-class)]. Straight counts were performed in Excel, but for statistical analyses JMP 8 was generally used. Means and standard deviations (SD) are reported. To analyze differences in the average between multiple groups for continuous data, the Tukey–Kramer (Honestly Significant Difference) multiple comparison procedure was used as a parametric method and the Kruskal–Wallis analysis of variance (ANOVA) as a non-parametric method. For analyzing ordinal and nominal data, the Pearson χ^2 test was used and the results are reported as odds ratios (OR) with 95% confidence intervals (CIs). All tests were done at significance level 0.05. To search for factors with potential impact on prescription rates, we conducted a multinomial logistic regression analysis, and to adjust for differences in patient and nursing home characteristics we performed a two-way ANOVA.

Results

The nursing homes were comparable in terms of nursing staff (county standard), financing (public, not private) and residents' gender distribution (Pearson χ^2 test), Table 1. Two institutions had a significantly lower mean age (Tukey–Kramer) than the others, nursing homes F and G. Median age was between 82.7 and 87.3 years for all institutions.

Medications in general

The total number of prescriptions recorded was 3468. The average number of regular drugs was 6.1 per patient ($n = 513$, SD = 3.3, range: 0–20). Classified according to principal ATC groups (Skrbo *et al*., 2004), the three most frequent were drugs for the 'nervous system', 'digestive organs and metabolism' and 'heart and circulation' (Table 2). Paracetamol was the most frequently prescribed drug (regular *and* as-needed) with 5.7% ($n = 197$) of the total number of prescriptions ($n = 3\,468$), administered to 38.4% of the patients.

The average number of as-needed drugs per patient was 3.8 ($n = 513$, SD = 2.2, range: 0–14).

Prescriptions of psychoactive drugs by way of regular or as-needed prescriptions are shown in Table 3. Of 513 patients, 24.4% (125) were regularly given one or several neuroleptics, 9.7% (50) of the patients ($n = 513$) had neuroleptics by way of an as-needed prescription and 6.4% (8) of the patients on regular neuroleptics ($n = 125$) were using two different ones regularly. Risperidone was the most frequent antipsychotic drug, and haloperidol was the most frequent as-needed neuroleptic.

Of all, 14.6% (75) of the patients ($n = 513$) were on opioids (N02A) by way of regular medication and 28.7% (147) by way of an as-needed drug, and 41.5% (215) of the patients received antidepressants as regular medication.

On the basis of our figures, prevalences of long-term patients in nursing homes being prescribed psychoactive medication were as follows: neuroleptics regular 244/1000 and as-needed 98/1000; antidepressants regular 419/1000; anxiolytics regular 220/1000 and as-needed 415/1000; and opioids regular 146/1000 and as-needed 287/1000.

Table 1 Nursing home characteristics: characteristics of the seven nursing homes with long-term patients participating in the city of Bergen, Norway, in 2008 ($n = 513$ long-term patients)

Nursing home	A	B	C	D	E	F	G	Total	*P*
n	83	77	39	85	82	101	46	513	
No. of places (total/long/short)	108/88/20	84/63/21	66/31/35	90/90/0	107/81/26	131/99/32	64/48/16	650/500/150	
Location in city	Suburb	Inner city	Suburb	Suburb	Inner city	Suburb	Suburb		
Doctors' hours per place per week	0.4	0.3	0.5	0.3	0.4	0.4	0.5	0.4	<0.0001[1]
Men (%)	33.7	33.8	28.2	26.7	21.0	37.6	30.4	30.2	0.2731[2]
Age (years)									
Mean	86.7	85.2	84.7	84.9	88.2	79.6	82.2	84.4	0.0001[3]
SD	7.6	10.7	7.5	9.1	6.8	15.7	10.0		
Length of stay (days)									
Mean	990.0	901.5	973.1	946.1	1728.9	1383.1	1055.2	1171.5	<0.0001[4]
(±SEM)	(±115.8)	(±121.8)	(±169.0)	(±115.8)	(117.2)	(±106.5)	(±169.0)		
Median	1102.9	1038.8	747.8	854.7	1071.6	1299.9	873.4		
Median test	−2.3	−1.4	−0.5	−1.8	4.5	1.0	0.2		
Non-demented (%)	20.7	31.6	0.0	29.4	41.4	20.8	19.6	23.4	0.0005[5]
Deviation	−3.8	+4.7	−9.9	+3.4	+13.2	−4.7	−2.7		
Suffered stroke (%)	29.3	7.9	28.2	34.1	20.7	26.7	13.1	22.8	0.0115[6]
Deviation	+4.5	−12.1	+1.9	+9.1	−2.2	+3.6	−4.8		

SD = standard deviation; SEM = standard error mean.
[1] Kruskal–Wallis test.
[2] Pearson χ^2 test.
[3–4] Wilcoxon test.
[5–6] Pearson χ^2 test.

Table 2 Prescriptions per ATC main groups: ranking of the number of prescriptions according to the classification of the ATC Drug Register among long-term patients at seven nursing homes in Bergen, Norway ($n = 513$)

Principal ATC group	ATC group name	No. of prescription	%
N	Nervous system	1107	31.9
A	Digestive organs and metabolism	851	24.5
C	Heart and circulation	553	15.9
B	Blood and blood-forming organs	389	11.2
R	Respiratory organs	140	4.0
H	Hormones systemically, without sex hormones and insulin	83	2.4
G	Urogenital system and sex hormones	81	2.3
S	Sensory organs	80	2.3
M	Muscles and skeleton	59	1.7
J	Anti-infectants for systemic use	57	1.6
D	Dermatological agents	44	1.3
L	Antineoplastics and immune modulators	23	0.7
P	Antiparasitics	1	0.0
	Total number of prescriptions	3468	100.0

ATC = anatomical therapeutic chemical.

Table 3 Psychoactive drugs: ranking of the most prescribed drugs affecting the central nervous system among 513 long-term patients at seven nursing homes in Bergen, Norway

Regular drugs				As-needed drugs			
ATC code*	Drug group	Patients with drug		ATC code	Drug group	Patients with drug	
		n	%			*n*	%
N06A	Antidepressants	215	41.5	N02B	Analgesics/antipyretics	227	44.2
N02B	Analgesics/antipyretics	206	40.2	N05B	Anxiolytics	213	41.5
N05A	Antipsychotics	125	24.4	N02A	Opioids	147	28.7
N05B	Anxiolytics	113	22.0	N05C	Hypnotics and sedatives	108	21.1
N05C	Hypnotics and sedatives	99	19.3	N05A	Antipsychotics	50	9.7
N02A	Opioids	75	14.6	N03A	Antiepileptics	3	0.6
N06D	Antidementics	65	12.7	N06A	Antidepressants	3	0.6
N03A	Antiepileptics	58	11.3				
N04B	Dopaminergics (anti-Parkinson's)	20	3.9				
N04A	Anticholinergics (anti-Parkinson's)	9	1.8				
N06B	Psychostimulants	1	0.2				
N02C	Migraine drugs	0	0.0				

ATC = anatomical therapeutic chemical.

Differences among the nursing homes

We discovered some significant correlations in the total material that could bias the differences between nursing homes. Morphine is given less in the nursing home where the physician was a specialist (Pearson, $P = 0.0097$) as were neuroleptics (Pearson, $P = 0.0139$). Neuroleptics were given more to patients suffering from dementia ($P = 0.0259$); fewer benzodiazepines were given with increasing age ($P = 0.0066$); the longer the stay, the fewer the antidementics that were given ($P = 0.0001$); and patients on antidepressants had a lower age ($P = 0.0002$). However, analyzing differences among institutions, correcting for these factors and for age and sex, impacted only slightly on some *P*-values, although not on the total picture.

We discovered significant differences between nursing homes as a percentage of patients on drugs within the actual ATC main group. Differences

Table 4 Institution differences, psychoactive drugs: proportions of long-term patients on one or more regular and as-needed psychoactive drugs prescribed in seven (A, B…) nursing homes in Bergen, Norway, 2008

	A	B	C	D	E	F	G	*P*
Morphine regular	0.08	0.13	0.31	0.19	0.18	0.15	0.04	0.0118
Neuroleptics regular	0.36	0.27	0.13	0.32	0.26	0.14	0.15	0.0029
Anxiolytics regular	0.30	0.19	0.26	0.26	0.18	0.23	0.09	0.1111
Hypnotics regular	0.19	0.19	0.18	0.22	0.17	0.19	0.24	0.9677
Antidepressants regular	0.41	0.42	0.49	0.56	0.22	0.40	0.48	0.001
Antidementia regular	0.11	0.14	0.26	0.13	0.07	0.12	0.13	0.2022
Morphine as-needed	0.34	0.27	0.46	0.29	0.34	0.16	0.30	0.0149
Neuroleptics as-needed	0.07	0.08	0.10	0.05	0.21	0.12	0.02	0.0058
Anxiolytics as-needed	0.47	0.42	0.36	0.47	0.30	0.43	0.43	0.3329
Hypnotics as-needed	0.17	0.23	0.23	0.21	0.22	0.23	0.22	0.9644
Antidepressants as-needed	0.00	0.03	0.00	0.00	0.00	0.00	0.02	0.141
Antidementia as-needed	na	na	na	na	na	na	na	

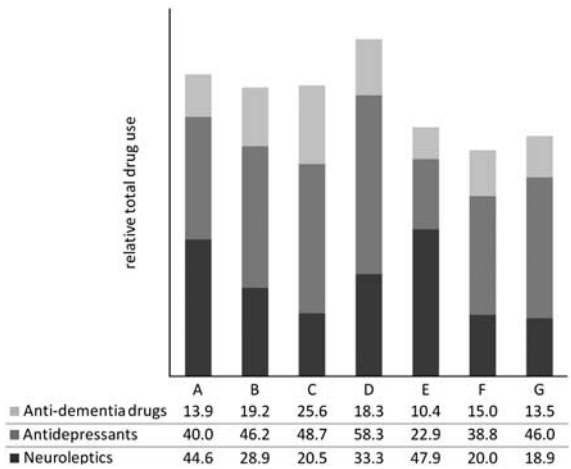

Figure 1 Use of three different psychoactive drugs among long-term demented patients at seven nursing homes (A, B…) in Bergen, Norway. Differences between institutions are significant for neuroleptics (Pearson χ^2 test, $P = 0.0016$) and antidepressants ($P = 0.566$). Differences are not impacted by corrections for age and sex.

were highly significant statistically for morphine (Pearson χ^2 test, $P = 0.0117$), neuroleptics ($P = 0.0026$) and antidepressants ($P = 0.0010$), Table 4. Comparison of drug use among the patients with reduced cognitive functions by institution is demonstrated in Figure 1. Differences between institutions were significant for neuroleptics (Pearson χ^2 test, $P = 0.0016$) and antidepressants ($P = 0.0010$) but not for antidementics ($P = 0.566$).

The addition of DDDs and calculating total drug use per institution even increased the differences, and the differences were highly significant for all drug classes, Table 5 and Figure 2.

Neuroleptics – Parkinsonism

Five out of 18 patients being given drugs for Parkinsonism were also on neuroleptics. One of the patients was a psychiatric patient on biperiden. One was being given quetiapine, which is an atypical neuroleptic not contraindicated in the case of Parkinsonism. Three could be characterized as possibly harmful medications. On the basis of our material, the prevalence of current medication was 2/1000 among all long-term nursing home patients.

Medication for patients with impaired cognition

Patients with impaired cognitive function were prescribed significantly fewer regular drugs than patients without impairment. The average for patients without impairment was 7.1 drugs ($n = 130$) and for the patients with impaired cognitive functions 5.7 drugs ($n = 381$, Wilcoxon test, $P < 0.0001$). There was no difference in the number of as-needed drugs for the two patient groups. Among patients with impaired cognitive functions, 21.0% had suffered stroke, and among patients without impairment 32.0% (OR: 1.76, 95% CI: 1.13–2.75). In general, there was a tendency to lower the prescription rate of all cardiovascular drugs for the patients with reduced

Table 5 Total psychoactive amount (DDD): differences of regularly prescribed psychoactive drugs in seven nursing homes in Bergen, 2008, expressed by the parameter (total DDD per drug class prescribed) × (per institution percentage of patients on drugs of actual class)

	A	B	C	D	E	F	G	*P*
Morphine	0.07	0.34	5.21	0.33	0.62	0.34	0.17	<0.0001
Neuroleptics	4.02	2.76	0.72	9.69	3.06	0.66	0.86	0.0034
Antidepressants	14.89	21.92	28.57	36.74	4.35	17.42	38.71	0.0001
Antidementia drugs	1.32	1.89	5.14	1.75	0.40	1.24	1.51	0.0071
Anxiolytics	2.86	1.56	5.78	2.38	1.73	1.72	0.28	0.0002
Anotics	1.97	2.79	2.31	4.84	2.02	2.64	5.37	0.0001

DDD = Defined Daily Dosages.

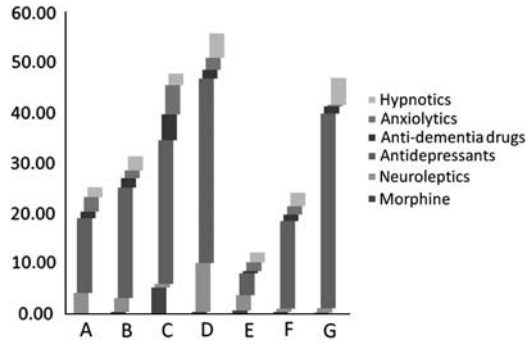

Figure 2 Total use (percentages × Defined Daily Dosage – DDD) for long-term patients on regularly prescribed psychoactive drugs in seven (A, B…) nursing homes in Bergen, Norway, 2008. Also see Table 5.

cognitive functions, significantly for angiotensin converting enzyme inhibitor or angiotensin II receptor blocker – ACEI/A2B (OR: 1.78, 95% CI: 1.07–2.94) and diuretics (OR: 1.77, 95% CI: 1.18–2.66). Neuroleptics were more frequently prescribed to patients with reduced cognitive functions (31%/21%, OR: 0.58, 95% CI: 0.36–0.94). ProBNP (brain natriuretic peptide) was significantly higher in the patient group without cognitive impairment (Wilcoxon, $P = 0.0011$). No such differences existed for atrial fibrillation (Pearson χ^2 test, $P = 0.137$) or renal function (Estimated Glomerular Filtration Rate, Wilcoxon, $P = 0.1918$). Significant negative correlation was found between age and weight (Pearson χ^2 test, $P < 0.0001$), and the average age among patients with reduced cognitive functions was lower than the rest of the population (Wilcoxon, $P = 0.0407$). Average patient weight was 62 kg, half of all patients ($n = 513$) having weight loss last 30 days.

Associations

With regard to comorbidity, we did not find any associations with the use of neuroleptics and stroke suffered, or associations between neuroleptics and patient weight or weight loss/30 days. Use of antidepressants was positively associated with patient weight (Wilcoxon test, $P = 0.0037$). No associations for benzodiazepines or hypnotics were found with stroke, weight or weight loss.

Discussion

The number of drugs given to nursing home patients in Bergen is higher than the number given 10 years ago. Considerable treatment rate differences existed between institutions. Patients with cognitive problems were prescribed fewer drugs in general but more neuroleptics. Except for significantly higher weight in patients on antidepressants, none of the other clinical factors tested for associations with psychoactive drugs was significant.

Limitations of the study

The role of nursing homes in the delivery of social and health care services differs between, as well as within, countries. Nursing homes in many countries are managed as part of social care. In Norway, nursing homes are regulated as a health care service. These differences may influence the health issue landscape and composition of staff. Thus, comparisons and generalizations based on our findings should be done with care.

For most planned purposes, we consider our material valid and robust with regard to both sample size and tested parameters. However, the size of the material may be too small to calculate the prevalence of rarer diagnoses/drugs. A weakness

of our study is that comparisons between diagnosis and drug treatment cannot be performed.

The simple test we used to decide whether or not patients had reduced cognitive functions can be questioned (Berger, 1980). Using Minimal Mental Score was beyond project resources. Our method was to a certain degree validated, however, by comparing the extent to which dementia drugs were given to patients scoring above 0 (reduced cognitive functions), giving a 95% overlap, and to a certain degree by medical record data. We thus found our method sufficient for the purposes of the study.

Earlier research

We found good concordance with results from previous studies in terms of the drug groups most frequently prescribed (N, A, C, B, R; Nygaard, 2001). In our material, ATC group G (urogenital system and sex hormones) was used less than previously demonstrated. References to the use of these drugs are some years old, and drugs and diagnostics have evolved, which is probably the reason for this.

The proportion of patients taking neuroleptics was slightly higher than previously demonstrated in Bergen nursing homes (23%, 2001). The decreasing use of neuroleptics in nursing homes discussed by other authors has not been verified (Ruths *et al*., 2001). This is surprising, given research showing the lack of effect of neuroleptics among patients suffering dementia. Neuroleptics *are* needed in nursing homes, but for limited periods and for individual patients, and more often than is currently the case. Patients often end up with a regular prescription without any evaluation of the need to pause treatment and take stock after a period of time (Selbaek *et al*., 2008).

The use of neuroleptics for patients with Parkinson's is low because of the low prevalence of Parkinson's (5.5%); however, the number of these patients with a drug combination that includes neuroleptics that are contraindicated is probably not negligible.

In our study, the prescription of antidepressants was similar to a comparable study in Bergen in 2001 (Ruths *et al*., 2001). An increase was expected. The selective serotonin reuptake inhibitor drugs (SSRIs) are important drugs for the elderly. Even in our study, we found a positive association between SSRI use and patient weight. However, interactions with certain drugs (antiepileptics, neuroleptics, cimetidine and codeine) do exist and they increase the risk of bleeding for patients on warfarin without impacting the International Normalized Ratio. Non-steroidal Anti-inflammatory Drugs together with SSRIs increase the risk of gastrointestinal bleeding (Van Der Steen *et al*., 2009).

Weight gain during antidepressant treatment can be either a sign of improvement in patients who have weight loss as a symptom of depression or a drug side effect. However, significant weight gain during the acute phase of treatment or weight gain that continues despite achieving full remission of depressive symptoms is likely to be a side effect of antidepressant treatment. Weight gain is a relatively common problem during both acute and long-term treatment with antidepressants (Fava, 2000). In our material, the average patient weight was 62 kg, half of the patients suffering weight loss. The unwanted side effect by antidepressants in a common population may be an advantage among nursing home patients. More research is needed to shed more light on this issue. However, in our study, the lower age among patients with reduced cognitive functions may to a certain degree explain the higher weight in this group, as weight decreased by age, significantly.

The hazard from falls and fractures when on psychoactive drugs is well known (Gales and Menard, 1995; Kiel *et al*., 2007). In Norway, $\sim$9000 hip fractures (50% among persons >85) are treated in hospitals, giving a yearly age-independent incidence of 2/1000 and for the population >85 $\sim$9/1000 (Van Der Steen *et al*., 2009). In Bergen, yearly 90 hip fractures among 2300 nursing home beds were registered over 12 months, 2006−2007, giving an incidence of 39/1000 (Krüger *et al*., 2011). The prevalence of hip fractures has also been estimated by other authors (Dobnig *et al*., 2006; Kiel *et al*., 2007). More differentiation in the use of psychoactive drugs for patients at risk of falling could prove valuable, like patients with/without the ability to walk unaided.

A lower cardiovascular drug consumption by nursing home patients suffering reduced cognitive functions has been reported by others (Nygaard *et al*., 2003). This may reflect a selection effect as the majority of nursing home patients are admitted because of dementia (75–80%), and the others due to somatic illnesses, for example,

cardiovascular diseases. However, general cardiovascular risk factors are also risk factors for developing Alzheimer's disease and the combination of cerebrovascular and degenerative causes make up a large proportion of all dementias. That ProBNP was significantly higher among patients without cognitive impairment indicates that morbidity differences may exist between the two groups, in nursing homes, with regard to cardiovascular disease. In contrast, no such differences existed for atrial fibrillation or renal function. The reasons for lower treatment rate among patients in nursing homes with impaired cognitive functions still remain unclear.

Differences between nursing homes

In our study, we have tried to evaluate the present status and have demonstrated sizable differences between the nursing homes when it comes to the use of medications, which cannot be explained by different prevalences alone. This was evidenced by our own research on the association between atrial fibrillation and stroke and warfarin, and it is logical to assume that it obtains for psychoactive drugs as well (same material, different publication). Drug differences and physician staffing have been indicated (Kersten *et al*., 2009), but the reasons for such differences are probably multifactorial, as is quality in general. Both employee skills and attitudes probably play a role, as do management, routines, tracking systems and a collaborative work climate. We did not see any bias because of sex, age and staffing differences between nursing homes or when blocking other potentially biasing factors discovered by multiple regression analysis. Calculating the total use of drugs within each drug class using DDDs, increased the differences between institutions, Table 5 and Figure 1. This probably shows that institutions with a high percentage use are also using higher dosages.

Documenting quality status and improving quality in nursing homes is a challenge. Internationally, several quality improvement studies have been undertaken: Nursing homes with a smaller number of beds, operating for profit and having a high level of nursing staff may improve quality (Wan *et al*., 2006). It has been claimed that marginalization of physicians in the nursing home threatens the overall care of increasingly frail nursing home residents who have medically complex illnesses (Katz *et al*., 2009). Medication quality improvement efforts in nursing homes should probably focus on the medications commonly implicated in errors and should continue to discourage or closely monitor the use of medications considered potentially inappropriate in the elderly (Hansen *et al*., 2006). A menu-driven incident-reporting system has the potential to enhance quality improvement efforts in nursing homes (Wagner *et al*., 2005). In pain management, a multifaceted collaborative intervention proved valuable, involving audit and feedback on pain management, education, training, coaching using rapid-cycle quality improvement techniques and inter-nursing home collaboration (Baier *et al*., 2004). It has been shown that there exists a relationship between ambitious targets and nursing home quality (Baier *et al*., 2009). Implementing small, focused and inexpensive interventions, like monitoring BP controls, can improve quality (Choma *et al*., 2009).

Simply providing comparative performance feedback may not be enough to improve resident outcomes (Rantz *et al*., 2001). Targeting specific drugs in the surveyor's interpretative guidelines as a method of reducing potentially inappropriate medication use does not produce the desired gains in terms of improving the quality of medication use either (Lapane *et al*., 2007).

It is difficult to envisage adequate quality control without the use of modern technology like medical record systems with alarms, statistics and decision-making support in addition to already proven tools for improving the quality of drug use. The effectiveness of decision support tools has been shown in several studies and should be tested in nursing homes (Ornstein *et al*., 2004; Kawamoto *et al*., 2005).

Conclusions

There are differences in treatment with psychoactive drugs between nursing homes. Treatment differences also exist between patients with/without cognitive impairment but reasons remain unclear. Improvement strategies and more research are needed. The proportion of patients per institution on selected drugs can serve as a feedback parameter in quality systems, but adding DDDs increases differences.

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ORIGINAL RESEARCH

Atrial fibrillation and heart failure in seven nursing homes

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Abstract

Objectives: Previous research suggests that blood-thinning treatment for patients with atrial fibrillation as well as treatment for patients with heart failure is not adequate among the elderly. We tested this among long-term patients in nursing homes.

Methods: Information about the patients (n = 513) was collected during the period March-April 2008. Data collection consisted of electrocardiography, particulars of any stroke suffered and copying medication records. A standardized set of blood samples was analyzed.

Results: Of the 91 atrial fibrillation patients, 14.3% were anticoagulated with warfarin. 42.0% of the patients with atrial fibrillation had no form of antithrombotic treatment. Prevalence of atrial fibrillation was 18.8% and high B-type natriuretic peptide (ProBNP > 225 pmol/L) 13.2%. Of the patients with both stroke and atrial fibrillation, 24.3% were given warfarin. Of the 59 patients with ProBNP > 225 pmol/L and adequate renal function (eGFR > 50 ml/min), 22.0% were given ACE/A2B.

Conclusions: The warfarin treatment rate was lower than recommended for patients with atrial fibrillation in nursing homes, as was probably the use of ACE-inhibitors to heart -failure patients. We found significant differences between the nursing homes with regard to treatment rate. Atrial fibrillation and heart failure case finding and monitoring in nursing homes needs to be improved and simple tools like recording and reporting irregular pulse by doctors and nurses and measure ProBNP on a regular basis may improve this.

Key words

Nursing home, Atrial fibrillation, Heart failure, Drugs, Long-term care, Chronic disease

1 Introduction

Norway has 4.6 million inhabitants, 55 public hospitals, 41,052 nursing home beds and 1,796 beds in old people's homes; 96.8% of nursing home beds are in single rooms and 43.3% of all deaths (total 41,342) are in nursing institutions [1]. The

healthcare system is split into first and second line services. First line services are administered and financed by the municipalities (N = 431). First line covers general practice (GP) services, mother and child care, home-care and nursing homes (N = 900). The second line contains the 55 hospitals and specialist services (including private specialists). Second line is administered and financed directly by the state.

It is expected that nursing homes will play an important role in healthcare delivery in the years ahead. The population is growing older and patients admitted to hospitals are being discharged earlier. A Norwegian white paper states that a reform is needed to ensure collaboration between primary care and hospitals. After US, Norway (2009) spends the most money per capita on health in the world (www.oecd.org), but does not get the most in return for the investments. Poor cooperation between first- and second line services is regarded as the main obstacle to improvements [2]. Among several proposals, the white paper points to accomplishments involving early discharges from hospitals to nursing homes which offer more advanced medical care and structured rehabilitation programs than previously. Quality in the nursing homes will thus be under pressure, expectations of services will rise and clinical complexity will grow. New strategies and more knowledge about the nursing home population are needed to meet this situation.

Two of the most frequent diagnoses among the elderly (> 75) are atrial fibrillation (AF) and congestive heart failure. The prevalence of AF has not been studied in Norwegian nursing homes, nor has the way AF is treated. The question of under-treatment of heart failure in nursing homes has been raised earlier [3].

AF is an independent risk factor for developing a stroke [4], and in the elderly it is one of the most important causes of stroke [5]. The current guidelines state that most patients over the age of 75 with atrial fibrillation should be anticoagulated with warfarin. However, increasing age often leads to lower treatment rate than among younger patients [6, 7]. Stroke risk in AF patients can be estimated using the CHADS2 score, which is a clinical prediction rule for estimating the risk of stroke in patients with non-rheumatic atrial fibrillation [8]. "Patients are given points on the basis of clinical variables – heart failure: 1 point, hypertension: 1 point, over 75 years of age: 1 point, diabetes: 1 point, previous stroke or transient ischaemic attack (TIA): 2 points. The annual risk of stroke is: CHADS2 score 0: 1.9%, 1: 2.8%, 2: 4.0%, 3: 5.9%, 4: 8.5%, 5: 12.5%, 6: 18.2%". By one (1) point warfarin or aspirin is recommended, by $\geqslant$ 2 points warfarin treatment is recommended.

To estimate the risk of bleeding for AF patients on warfarin treatment, bleeding risk scores can be used [9]: "Bleeding risk score = 0.49· X (Age >70) + 0.32· X (Female) + 0.58· X (Remote bleed) + 0.62· X (Recent bleed) + 0.71· X (Alcohol/Drug Abuse) + 0.27· X (Diabetes) + 0.86· X (Anaemia) + 0.32· X (Antiplatelet), where X equals 1 when the specific characteristic is present and 0 otherwise. Bleeding risk scores of > 1.07, > 1.07 but < 2.19, and > 2.19, respectively, are classified as low, moderate and high risk. Low-risk individuals have 0.9% bleeding risk, moderate-risk 2.0% and high-risk individuals 5.4%". In the study cited the high-risk bleeding individuals (5.6% bleeding risk) had a 7% stroke risk.

Simple diagnostic tests are needed in nursing homes to diagnose the most frequent conditions. Transports to hospitals may be exhausting for frail and old nursing home patients. Research shows that ProBNP, which is an amino acid secreted by the ventricles of the heart in response to excessive stretching of heart muscle cells (cardiomyocytes), provides useful diagnostic information supplementary to clinical examination in order to diagnose untreated heart failure in the elderly [10]. This refers both to left ventricular function [11] and diastolic dysfunction [12]. To monitor heart failure treatment using repeated measurements of ProBNP in blood is probably better than traditional methods like clinical examination and echocardiography [13].

We wanted to investigate to what degree long-term nursing home residents with AF received antithrombotic treatment and to what extent patients with NT-proBNP above 225 pmol/L were treated with angiotensin-converting enzyme (ACE) inhibitors/A2 blockers, beta-blockers, statins and diuretics, and to shed light on the biasing effect of renal failure, weight and age on ProBNP. We also wanted to study whether there were differences in treatment between the nursing homes.

The study was approved by the Regional Ethics Committee of Western Norway.

2 Materials and methods

Bergen has 250,000 inhabitants and 37 nursing homes (2,300 beds). The number of beds ranges from 20 to 189. Seven nursing homes in Bergen participated in this study. Only long-term patients (n = 513) were included. The nursing homes were comparable in terms of nursing staff, financing and gender distribution.

Information about the patients was gathered during the period March-April 2008. 24 medical students conducted the data collection, which consisted of weight, details of any stroke suffered and copying of drug charts. Electrocardiography was conducted to diagnose AF and a standardized set of blood samples were analyzed at the laboratory at the Bethany Hospital (haemoglobin, B-type natriuretic peptide (ProBNP), sodium, potassium, calcium, albumin, creatinine, blood urea nitrogen, urate, estimated glomerular filtration rate (eGFR)). 447 of the patients were blood-tested and 484 ECG'ed. 488 of the patients were weighed. It was possible to conclude if the patient had undergone a stroke in 462 of the patients. Complete medication records existed for all patients.

We used ProBNP > 225 pmol/L to define patients with heart failure. To understand the degree of the biasing effects of age, weight and renal function on ProBNP-levels in this population, we performed bivariate analyses of the factors mentioned and quantified explained variation by the determination coefficient (R^2). We also estimated non-parametric correlation (Spearman's) between ProBNP and eGFR, as renal function is considered the most important biasing factor for ProBNP. To try to find a predictive equation taking all biasing factors into consideration, a multiple linear regression analysis of the square root of proBNP on age, weight and the square root of eGFR was performed.

The recorded data were keyed into an Excel worksheet and the drugs coded according to the Anatomical Therapeutic Chemical Drug Register (ATC). Frequency counts were performed in Excel, but the statistical analysis software JMP version 8 (from SAS), was used for general statistical analysis. To analyze differences in average of continuous data (e.g. ProBNP) the Tukey-Kramer (Honestly Significant Difference) multiple-comparison method was used as a parametric method (- assumes that the data has come from a type of probability distribution and makes inferences about the parameters of the distribution) and the Wilcoxon test as a non-parametric method (- which do not rely on assumptions that the data are drawn from a given probability distribution). Pearson's chi-square test was used to analyze ordinal and nominal data. Results were reported as odds ratios (OR) or relative risks (RR) with 95% confidence intervals (CI), estimated directly from 2 × 2 tables. All tests were done at the 5% significance level.

3 Results

513 long-term patients residing in seven nursing homes were included. 69% were women, 31% men. The mean age was 84.1 years. Nursing home characteristics are demonstrated in Table 1 and use of cardiovascular drugs are shown in Table 2.

3.1 Atrial fibrillation

91 (18.8%) of the 484 patients with recorded electrocardiography had AF. There was no significant difference in the occurrence of AF among nursing homes (Pearson's chi-square test: $p = 0.4858$). 13 (14.3%) of the 91 AF patients were anticoagulated with warfarin, 85.7% (78) were not. AF patients were given ASA more than the group without AF (OR = 1.73, 95% CI: (1.07, 2.78), Pearson's chi-square test: $p = 0.0231$).

There were significant differences in warfarin treatment to AF-patients among nursing homes (from 0 to 50%) as demonstrated in Figure 1.

The average CHADS2 score for AF patients (91) was ranged from 4 - 6, which corresponds to an annual stroke risk of 8.5-18.2%. These estimates were based on counting score-giving parameters: Most of the AF patients were older than 75 years old (87%), giving CHADS2 score "1". We found that 41% of AF patients had undergone a stroke before, 30% had ProBNP > 225 pmol/l, 30% were given ACE inhibitors/A2 blockers, 13% anti-diabetics, 57% diuretics, 23% beta-blockers and 12% calcium antagonists, all indicating score-giving illness according to the CHADS2 score.

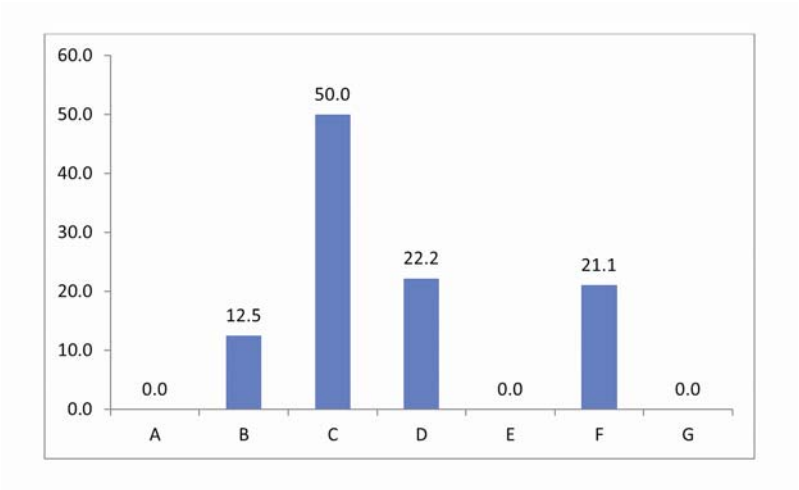

Figure 1. Percentage of long-term patients with atrial fibrillation (N=91) receiving warfarin in 7 nursing homes (A, B....) in Bergen, Norway (Pearson's chi-square test: $p = 0.0391$).

Table 1. Characteristics of the 7nursing homes with long-term patients participating in the city of Bergen, Norway, in 2008 (N =513 long-term patients)

Nursing home	A	B	C	D	E	F	G	Total	*P*
N	83	77	39	85	82	101	46	513	
No. of places (total/long/short)	108/88/20	84/63/21	66/31/35	90/90/0	107/81/26	131/99/32	64/18/46	650/500/150	
Location in city	suburb	inner city	suburb	suburb	inner city	suburb	suburb		
Doctors' hours per place per week	0.4	0.3	0.5	0.3	0.4	0.4	0.5	0.4	
Men (%)	33.7	33.8	28.2	26.7	21.0	37.6	30.4	30.2	0.273*
Age (years) Mean	86.7	85.2	84.7	84.9	88.2	79.6	82.2	84.4	<0.001**
Standard deviation	7.6	10.7	7.5	9.1	6.8	15.7	10.0		
Length (days) Mean	990.0	901.5	973.1	946.1	1728.9	1383.1	1055.2	1171.5	<0.001**
Standard deviation	1102.9	1038.9	747.8	849.6	1075.2	1299.9	873.43		
Non-demented n=511 (%)	20.7	31.6	0.0	29.4	41.5	20.8	19.6	23.4	<0.001*
Deviation (%)	-2.7	8.2	-23.4	6.0	18.1	-2.6	-3.8		
Suffered stroke n=426 (%)	32.4	10.2	28.2	35.4	21.5	30.0	15.4	24.7	0.009*
Deviation (%)	7.7	-14.5	3.5	10.7	-3.2	5.3	-9.3		

*Pearson Chi-square; **Kruskal-Wallis test

Table 2. Use of cardiovascular drugs for long-term patients in 7 nursing homes in Bergen, Norway. Left column shows the different Anatomical Therapeutic Chemical (ATC) drug groups. For each drug group and nursing home the percentage of patients using drugs within the relevant group is shown along with the deviation from the expected average.

Nursing home	A	B	C	D	E	F	G	All
N	83	77	39	85	82	101	46	513
ATC drug group								
C09, ACE/A2B, ACEI and A2 –blockers (%)	14.46	12.99	17.95	21.18	9.76	17.82	19.57	16.25
deviation	-1.79	-3.26	+1.70	+4.93	-6.49	+1.57	+3.32	
B01A, antithrombotics (%)	21.69	46.75	43.59	43.53	29.27	27.72	50.00	37.51
deviation	-15.82	+9.24	+3.09	+6.08	-8.24	-9.79	+12.49	
B01A, Albyl (%)	20.48	41.56	23.8	35.29	24.39	19.80	47.83	30.45
deviation	-9.97	+11.11	-6.65	+4.84	-6.06	-10.65	+17.38	
B01AA03, warfarin (%)	3.23	3.90	15.38	5.88	0.22	3.96	2.17	4,96
deviation	-1.73	-1.06	+10.42	+0.92	-4.74	-1.00	-2.79	
C03, diuretics (%)	38.55	33.77	48.72	45.88	50.0	25.74	26.09	38.80
deviation	-0.25	-5.03	+9.92	+7.08	+11.20	-13.06	-12.71	
C07, beta-.blockers (%)	13.25	20.78	23.08	24.71	13.41	15.84	19.57	18.66
deviation	-5.41	+2.12	+4.42	+6.05	-5.25	-2.82	+0.91	
C08, calcium channel blockers (%)	7.23	12.99	2.56	9.41	7.32	3.96	8.70	7.45
deviation	-0.22	+5.54	-4.89	+1.96	-0.13	-3.49	+1.25	

120 (23.4%) of the total cohort (N = 513) had at least one incident of stroke. 67 (55.8%) of patients who had suffered a stroke received some kind of antithrombotic treatment (ATC = B01A). 10 (8.3%) of these patients were given warfarin. 9 (24.3%) of 37 patients with both stroke and AF were given warfarin while 27 (73.0%) were given warfarin or some other antithrombotic treatment (B01AB/B01AC).

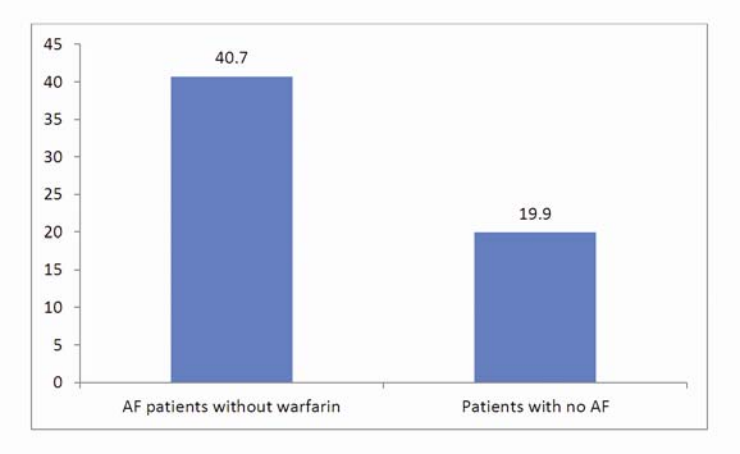

Figure 2. Difference in prevalence (%) of stroke suffered, between patients with AF without warfarin (37/91) as compared with patients without AF (78/391) among long-term nursing home patients in Bergen, Norway. ($p < 0.0001$, 95% CI 9.74% to 32.27%).

Patients with AF not receiving warfarin had strokes significantly more often (37/91 = 40.7%) than those without AF (78/391 = 19.9%) (N = 484, odds ratio = 2.75, 95% CI: (1.69, 4.47), Pearson's chi-square: p <0.0001). Patients with AF were 2.75 times more likely to have a stroke suffered than patients without AF (see Figure 2).

3.2 Heart failure / ProBNP

59 (13.2%) of the patients had ProBNP > 225 pmol/L. The average ProBNP value for all patients was 112.7 pmol/L (N = 447, SD 174.8, 95% CI: 96.5 to 129.0). There was no difference in average ProBNP values among nursing homes (ANOVA with Tukey-Kramer). Of cardiovascular related drugs, diuretics and heart glycosides were used significantly more in patients with ProBNP > 225 pmol/L. Of the 36 patients with ProBNP > 225 pmol/L and adequate renal function (eGFR > 50 ml/min.), 8 (22.0%) were given ACE/A2B. The different cardiovascular drugs used in patients with ProBNP > 225 pmol/L is presented in Figure 3.

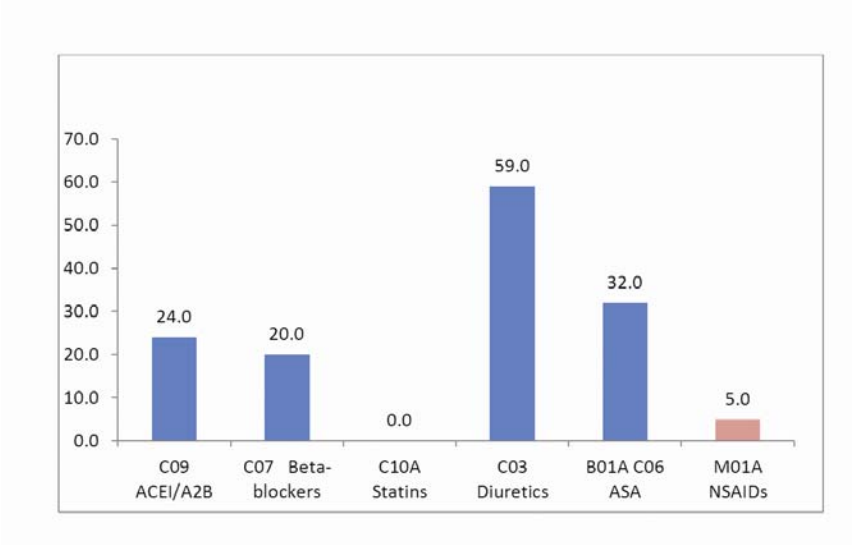

Figure 3. Percentage of patients with ProBNP > 225 pmol/l (N=59) using different heart failure treatments and NSAIDs (which are probably contraindicated).

Comparing the proportion patients using ACE -inhibitor or A2–blocker between the two groups of patients; A, with high proBNP (> 225 pmol/L) and adequate renal function (eGFR > 60 ml/min), (7/22) and B; those not having high ProBNP but adequate renal function (66/353), no significant difference was found (Pearson's chi -square test: p = 0.2370).

Patients younger than the median age (N = 221, 86.5 Years) had an average ProBNP of 77 pmol/L and patients older that the median age (N = 225) had an average ProBNP of 145 pmol/L (Wilcoxon p < 0.0001). Patients less than the median weight (61.1 kg) had an average ProBNP of 125 pmol/L and patients more than the median weight had an average ProBNP = 96 pmol/L (Wilcoxon, p < 0.0001).

Spearman's correlation between ProBNP and eGFR was -0.3914 (n = 446; p < 0.001) and doing a linear regression for sqrt(proBNP) on sqrt(eGFR) gave the following equation:

$$\sqrt{\text{proBNP}} = 19.457163 - 1.267237 \times \sqrt{\text{eGFR}}$$

and an R-squared of 0.1234 (see Figure 4). Having adequate renal function (eGFR > 60 ml/min) thus predicted a ProBNP < 92.93 pmol/l (= 19.457163 - 1.267237×√60) and eGFR = 12.37 ml/min is the renal function which predicts a ProBNP = 225 pmol/l (x = ((√225-19.457163)/1.267237)^2 = 12.3709014). No patients in our cohort (N = 513) had an eGFR that low.

From a multiple linear regression analysis of the square root of proBNP on age, weight and the square root of eGFR we found the following prediction equation:

$$\Pr oBNP = (17.651306 + 0.0630223 \times age - 0.070138 \times weight - 1.17 \times \sqrt{eGFR})^2$$

For example for an 80-year-old patient weighing 70 kg and having eGFR = 30 the predicted ProBNP is 129.39 pmol/L.

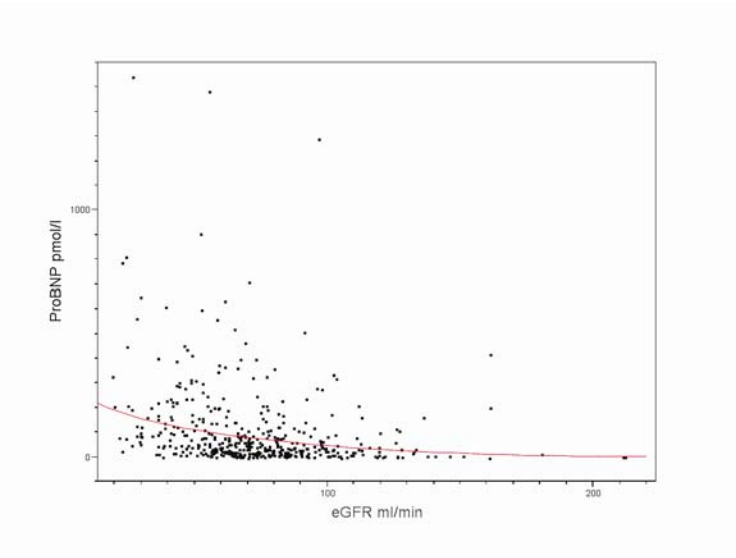

Figure 4. Correlation between ProBNP and eGFR among 446 long-term patients in nursing homes in Bergen, Norway (median age 86.5 years, median weight 61.2 kg). Linear regression for sqrt(proBNP) on sqrt(eGFR) gave the following equation: sqrt(proBNP) = 19.457163 - 1.267237*sqrt(eGFR) and an R-squared of 0.1234. eGFR 12.37 ml/min. is the renal function which predicts a ProBNP = 225 pmol/L (x = ((sqrt(225)-19.457163)/1.267237)¨2 = 12.3709014). eGFR 60 ml/min. predicts ProBNP 92.93 pmol/L.

4 Discussion

The prevalence of AF among long-term nursing home residents was 18.8% (91 of 484 ECG'ed). Of these patients, 14.3% (13) were treated with warfarin and 41.8% (38) had no antithrombotic treatment at all. The estimated CHADS2 score-based annual stroke risk for this AF-population was between 8.5 and 18.2%. Of 36 patients with ProBNP > 225 pmol/l and adequate renal function, 22.0% were treated with ACEI/A2B. There were significant differences in treatment of AF and use of heart failure drugs in patients with ProBNP > 225 pmol/L among nursing homes in the study.

The role of nursing homes in the delivery of social and healthcare services differs among countries as well as within countries. These differences may influence the health issue landscape and composition of staff. Thus comparisons and generalizations based on our findings should be made with care.

5 Limitations of the study

It may be claimed that using ProBNP as the only parameter to diagnose insufficiently or non- treated heart failure weakens the study and most procedures in force recommend echocardiogram to diagnose heart failure. On the other hand, an echocardiogram is often impractical as a diagnostic tool for nursing home patients both due to equipment price and physician qualifications. Transporting patients to a specialist cannot always be recommended for these frail patients either.

The cut-off value of ProBNP as a diagnostic tool for heart-failure in need of treatment, in different populations, is a matter of discussion. The high median age in our cohort made us go for a relatively high cut-off value (as increasing age leads to increasing ProBNP levels) even though that weakened sensitivity of the test. The main purpose of our study was however to examine if under-treatment existed in heart failure patients. Therefore, specificity (the proportion of negatives in the test which are correctly identified) was more important than sensitivity (proportion of actual positives which are correctly identified). We needed to be fairly sure to exclude healthy patients, missing some sick patients however, strengthens the under-treatment conclusion.

The identified risk by elevated ProBNP, whether it's a risk for death or a risk for heart failure hospitalization, lower values are better, higher values are worse. What one also knows, based on the data from Val-HeFT, is that while a single measurement is useful, serial measurements seem to inform even better prognostic value. This also refers to patients above 75 [14-16].

Cut-off limits of ProBNP as a diagnostic and prognostic tool in heart failure are discussed in numerous studies. In one study (mean age 73 years, followed for 6 years and registering all cardiovascular mortality) persons with ProBNP above 200 pmol/L had higher mortality [17]. In another study, 24 out of 25 patients were classified correctly with regard to heart failure, as compared with cardiac echo, using a ProBNP cut-off of 223 pmol/L [10].

Our results of bivariate fits of ProBNP by eGFR, weight and age (which are the known biasing factors), lead us to the conclusion that nursing home patients with a ProBNP > 225 pmol/L were more likely to have heart failure and, above this level, the high ProBNP values were not caused by high age, low weight or renal failure.

5.1 Atrial fibrillation

We found that 18.8% (91) of the patients had AF in our study population. The prevalence of AF has been found to be 17% for patients over 65 years and to increase with age [18]. Our prevalence is comparable to earlier findings and age groups. Patients with AF, older than 65, have been consistently undertreated with anticoagulants [19]. This is consistent with our finding that the warfarin treatment rate was low (14.3%). Even a warfarin treatment rate of about 65% of elderly AF-patients is considered problematic by several authors [9, 20]. In our study, we found a significant increase in stroke prevalence in AF patients not treated with warfarin, which illustrates under-treatment. Reasons for low treatment rates might be fear of intracranial haemorrhage and falls [20] but with systematic monitoring the risks associated with oral anticoagulation treatment appears to be low [21]. To start life-prolonging treatments may not always be as obvious to do in nursing home patients compared to younger patient groups. Suffering involved with stroke is considerable, however, and should be prevented if possible, at all ages.

Based on our estimates the stroke risk among nursing home residents with AF was 8.5-18.2%, considerably above 5.6% which is considered the highest bleeding risk score according to Shireman et al. [9]. Increased risk of bleeding episodes on warfarin treatment usually occurs among the elders aged within two months of start-up [22]. On the other hand, increased CHADS2 score (4-6) in the oldest (>85) population may increase bleeding risk [23]. Treatment must always be individualized therefore.

McCormick et al. [24] found that AF was present in 429 (17%) of 2,587 long-term care residents. Overall, 42% of these AF patients were receiving warfarin. This is consistent with our study when it comes to AF prevalence and more in line with our own opinion of a reasonable treatment level of frail nursing home patients than our own findings.

5.2 Heart failure/ProBNP

We found 13.2% (59) had a higher ProBNP (> 225 pmol/L). 8-10% was the prevalence rate for heart failure in earlier studies [25]. Only ten (16.7%) of the patients were given both ACE/A2B and diuretics, which suggests under-treatment. This impression is reinforced by the lack of significant ACE/A2B differences in treatment rates between the patient group

with high ProBNP and normal renal function (eGFR > 60 ml/min – giving a therapeutic indication without renal contraindication) compared to the rest of the cohort.

A high proportion of renal failure among the elderly has been considered to engender reservations in prescribing ACE inhibitors for this patient group [26]. However, it is not appropriate to withhold ACE inhibitors for heart failure in patients with only mild renal failure [27, 28]. Our findings show a low treatment rate in patients with adequate renal function as well.

6 Improvement strategies

It has been claimed that the marginalization of physicians in the nursing home is threatening the overall care of increasingly frail nursing home residents who have medically complex illnesses [29]. Staffing by trained doctors seems to be needed as well as training programs in treatment guidelines for AF and heart failure. Modern technological tools may be a way to increase treatment rate of warfarin to AF patients and ACE-inhibitors and A2-blockers to heart failure patients. Electronic patient records with reminders (e.g. "this patient has ProBNP > 250 pmol/L and normal renal function but receives no ACE-inhibitor or A2-blocker") have been proven effective in general practice and hospitals [30, 31]. Until now such tools have only been used or tested in a limited number of nursing homes [32].

7 Conclusion

Long-term patients with atrial fibrillation and heart failure in nursing homes are treated inadequately and dissimilarly. Strategies are needed to improve quality of cardiovascular treatments. Recording the irregular patient pulse by nurses and doctors and measuring ProBNP regularly may improve this. ProBNP levels in nursing home patients are probably not seriously biased by patient weight, age and renal function at levels above 225 pmol/L.

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Research Article

Can Electronic Tools Help Improve Nursing Home Quality?

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Background. Nursing homes face challenges in the coming years due to the increased number of elderly. Quality will be under pressure, expectations of the services will rise, and clinical complexity will grow. New strategies are needed to meet this situation. Modern clinical information systems with decision support may be part of that. *Objectives*. To study the impact of introducing an electronic patient record system with decision support on the use of warfarin, neuroleptics and weighing of patients, in nursing homes. *Methods*. A prevalence study was performed in seven nursing homes with 513 subjects. A before-after study with internal controls was performed. *Results*. The prevalence of atrial fibrillation in the seven nursing homes was 18.8%. After intervention, the proportion of all patients taking warfarin increased from 3.0% to 9.8% ($P = 0.0086$), neuroleptics decreased from 33.0% to 21.5% ($P = 0.0121$), and the proportion not weighed decreased from 72.6% to 16.0% ($P < 0.0001$). The internal controls did not change significantly. *Conclusion*. Statistics and management data can be continuously produced to monitor the quality of work processes. The electronic health record system and its system for decision support can improve drug therapy and monitoring of treatment policy.

1. Background

Nursing homes face challenges in the coming years due to an increased number of elderly. Quality will be under pressure, expectations of the services will rise, and clinical complexity will grow. New strategies are needed to meet this situation. Modern clinical information systems with decision support may be part of that.

1.1. Clinical Issues. Based on clinical experience and information about 513 long-term patients, we believed that there could be failure of the blood-thinning treatment of patients with atrial fibrillation. Likewise, we thought that weighing procedures were followed up for the poor. Use of neuroleptics for the oldest patients is under continuous debate. Therefore, we decided to focus on endpoints within these fields.

One of the most frequent diagnoses among the elderly is atrial fibrillation. Atrial fibrillation is an independent risk factor for developing a stroke [1], and in the elderly it is one of the most important causes of stroke [2]. The current guidelines in force are that all over-75s with atrial fibrillation are to be anticoagulated, but increasing age often produces the opposite effect with decreased prescriptions to the oldest [3, 4].

The presence of nutritional failure in Norwegian nursing homes has been questioned [5]. Little research in the field has been done so far. There is good evidence showing that inappropriate weight loss in the elderly materially impairs their quality of life and life prospects. The convalescence period for illness also increases substantially [6]. A significantly increased risk has been shown for secondary complications like pressure sores [7], infection, depression, and functional impairment [8, 9] as well as increased mortality [10–14].

The high consumption of psychopharmaceuticals in nursing homes has been emphasized in a number of studies. 23% of the demented nursing home population in Bergen was found to be on antipsychotics. The prevalence

of psychoactive drugs has been well documented earlier, but some years ago [15, 16]. Double-blind studies have shown little symptom reduction connected with the use of antipsychotics as compared with placebo [17, 18].

1.2. Decision Support. There are weaknesses involved in introducing consensus-based therapeutic regimes in a population. Often test results are not followed up. In a meta-analysis, Kawamoto and colleagues dealt with studies on the effectiveness of decision-making support tools and found that 68% of the systems showed significant improvement in practice [19].

A clinical decision support system (CDSS) is an application that analyzes data to help healthcare providers make clinical decisions. Decision-making support is closely correlated with structured record information, because the decision-making support tools have to respond to correct information in the record—for example, pathological test results. This is easier to accomplish if the underlying data are structured and standardized. A number of major European projects hinge on this issue [20].

The traditional medical approach focuses on the individual, with particular emphasis on symptoms, signs and test results emerging from the encounter with individual patients. In order to ensure accessible and correct treatment for all patients, it is also possible to operate using population-directed control measures, for example, keeping track of the proportion of a patient population on a specific drug. This is especially applicable in nursing homes where about 75% of patients are demented and cannot take responsibility for their own followup. The benefit of population-targeted intervention has also been proved in several studies [21].

The users' views on data systems are important for the real-term prospects of disseminating such tools. Doctors appreciate structured recording [22, 23]. Nurses' views on electronic patient records have been studied at a major hospital in Florida [24]. Of 100 nurses, one-third felt that electronic patient records resulted in a reduced workload and roughly the same proportion preferred being able to provide documentation at the patient's bedside, but said that this was often made difficult. A quarter thought that documentation was improved and the use of electronic patient records would improve patient safety. Nurses with experience of information technology consistently had more positive views than those without such experience.

In this project, we wanted to study whether decision support as part of an electronic, structured patient record system, together with targeted education, could improve the quality of medical treatment while avoiding negative impact on job satisfaction among users.

2. Material and Methods

We performed a prevalence study to quantify the proportion of long-term patients with atrial fibrillation that were being given warfarin, were taking neuroleptics, and had not been weighed for the last 30 days. Then, a before-after intervention study was done. The before-after study was conducted as a double cross-sectional design. Instead of randomization, we decided to use the proportion of patients on digitalis, thyroxin, and antidiabetics as internal controls (participants exposed to the same study, but these drugs were not part of any concrete intervention and were unlikely to undergo any changes by external factors.) [25]. The proportion of patients on neuroleptics was in addition followed as a time series (a sequence of data points, measured typically at successive times spaced at uniform time intervals) [26–28] in two nursing homes from 23 October 2008 to 15 July 2010.

2.1. Before-Data. The prevalence (before) survey was performed among long-term residents in seven nursing homes ($N = 513$). Bergen, Norway has approximately 250,000 inhabitants and 37 nursing homes (2,300 beds). The number of beds ranges from 20 to 189.

Information about the patients was gathered during the period March-April 2008. Medical students conducted the data collection, which consisted of copying medication cards, weighing by means of a local tool, but standardized clothing, and finding previously recorded weight/date. Electrocardiography (ECG) to diagnose atrial fibrillation was performed and a standardized set of blood samples analysed at the laboratory of the Bethany Hospital. The recorded data were keyed into Excel and the drugs coded according to the Anatomic Therapeutic Chemical (ATC) Drug Register.

The nursing homes were selected based on approximately similar size, function, and public ownership. They were comparable in terms of nursing staff and financing, but some differences existed with regard to other variables (Table 1).

2.2. Intervention. After quantifying clinical issues through the before-survey, we installed an electronic, structured patient record system which included decision support. The system had been developed and operating at Løvåsen educational nursing home (developing institution) for several years, funded by the Norwegian Medical Association and the Norwegian Research Council. Installation and training were carried out in the last quarter of 2008, and 6 of the 7 nursing homes were running the system on a daily basis from January 2009 for 12 months. After the active intervention period, the number of nursing homes running the system was reduced to three institutions, owing to contracts between Bergen Municipality and another vendor having been signed before the project started. Løvåsen Nursing Home and two of the study institutions continued and were the only institutions available for follow-up data. Data had to be collected directly from the electronic patient record system.

The technical intervention consisted of population filters and reminders. The system incorporated filters and alarms within several areas, but we decided to test 4 filters and 2 reminders. Population filters were predefined filters that produced lists of patients according to criteria in seconds. The tested population filters were (a) "patients taking neuroleptics" (list and proportion), (b) "patients taking warfarin" (list and proportion), (c) "patients with the diagnosis atrial fibrillation and their treatment status" (list and proportion), and (d) "patients not weighed for last 30

Table 1: Characteristics of the 7 nursing homes in the city of Bergen, Norway, participating ($N = 513$ long-term patients).

Nursing home	A	B	C	D	E	F	G	Total	P
N:	83	77	39	85	82	101	46	**513**	
No. of places, total/long/short	108/88/20	84/63/21	66/31/35	90/90/0	107/81/26	131/99/32	64/48/16	**650/500/150**	
Location in city	Suburb	Inner city	Suburb	Suburb	Inner city	Suburb	Suburb		
Doctors' hours per place per week	0.4	0.3	0.5	0.3	0.4	0.4	0.5	**0.4**	
Men, %	33.7	33.8	28.2	26.7	21.0	37.6	30.4	**30.2**	**0.273**[1]
Age, years									
Mean	86.7	85.2	84.7	84.9	88.2	79.6	82.2	**84.4**	<**0.001**[2]
Standard deviation	7.6	10.7	7.5	9.1	6.8	15.7	10.0		
Length of stay, days									
Mean	990.0	901.5	973.1	946.1	1,728.9	1,383.1	1,055.2	**1,171.5**	<**0.001**[2]
Standard deviation	1102.9	1038.9	747.8	849.6	1075.2	1299.9	873.43		
Nondemented $n = 511$, %	20.7	31.6	0.0	29.4	41.5	20.8	19.6	**23.4**	<**0.001**[1]
Deviation %	−2.7	8.2	−23.4	6.0	18.1	−2.6	−3.8		
Suffered stroke $n = 462$, %	32.4	10.2	28.2	35.4	21.5	30.0	15.4	**24.7**	**0.009**[1]
Deviation %	7.7	−14.5	3.5	10.7	−3.2	5.3	−9.3		

[1] Pearson' chi-square test; [2] Kruskal-Wallis test.

Table 2: User survey among employees in 7 nursing homes in Bergen ($N = 272$, 54%).

Sex	%	Age	%	Position	N	%
Male	12	<40	34	Nurse	97	37
Female	88	40–54	46	Assistant nurse	91	35
		>54	20	Physician	16	6
				Other	58	22

Table 3: Results from the user survey among employees in 8 nursing homes in Bergen, Norway, participating testing the "UNO GBD" electronic patient record system (2008–2010), a structured medical record system with decision-making support ($N = 272$, 54%).

(i) 65%—used application on a daily basis
(ii) 81%—exploited reminders when planned the work
(iii) 90%—documentation requirements were met
(iv) 67%—less time consuming
(v) 43%—increased job satisfaction
(vi) 72%—reminders supported them in doing the job
(vii) 83%—application contributed to safer medication

days" (list and proportion). Tested reminders visible in each patient's record, if the criteria were met, were (a) "patient has diagnosis of atrial fibrillation but is not on warfarin" and (b) "patient not weighed for last 30 days." Figures 1 and 2 demonstrate how this was arranged within the application.

Results from the before-study were presented to the participating doctors during the first 12 months of intervention through three two-hour lectures.

2.3. After-Data. Two institutions (E and F in Table 1) participated in the after-study. To collect the data we used the population filters in the medical record system to find the proportions of patients on endpoint drugs, internal controls, and patients not weighed for the last 30 days. Before-data were extracted from the prevalence study for institutions E and F ($N = 183$) for the before-after analysis. Institution E participated with an additional department (22 patients) in the intervention study ($N = 205$, after).

To study user satisfaction, we performed an anonymous survey among the doctors, nurses, assistant nurses, and physiotherapists ($N = 504$). Potential respondents were all users defined in the electronic system. They were invited by e-mail to respond to an electronic questionnaire. 16 questions about position and several aspects of their view on the functionality of the application were presented. Questions were closed, with a score from 1 to 5 (worse–better). The survey was constructed by a group of study nurses from the institutions, with technical organization by the vendor.

2.4. Statistics. For the prevalence (before) survey, the recorded data were keyed into an Excel worksheet and the drugs coded according to the Anatomical Therapeutic Chemical (ATC) Drug Register. To compare proportion of populations, Pearson's chi-square test was used. To compare distribution of continuous variables, Kruskal-Wallis' nonparametric one-way analysis of variance was performed. Straight counts were performed in Excel, but JMP 8 was generally used for statistical analyses.

3. Results

In the prevalence study, all long-term patients in 7 nursing homes were examined ($N = 513$). There were no dropouts. The before-after study included all long-term patients in two institutions ($N = 183$ before, 205 after), also no drop-outs. 272 (54%) users responded to the questionnaire, Tables 2 and 3.

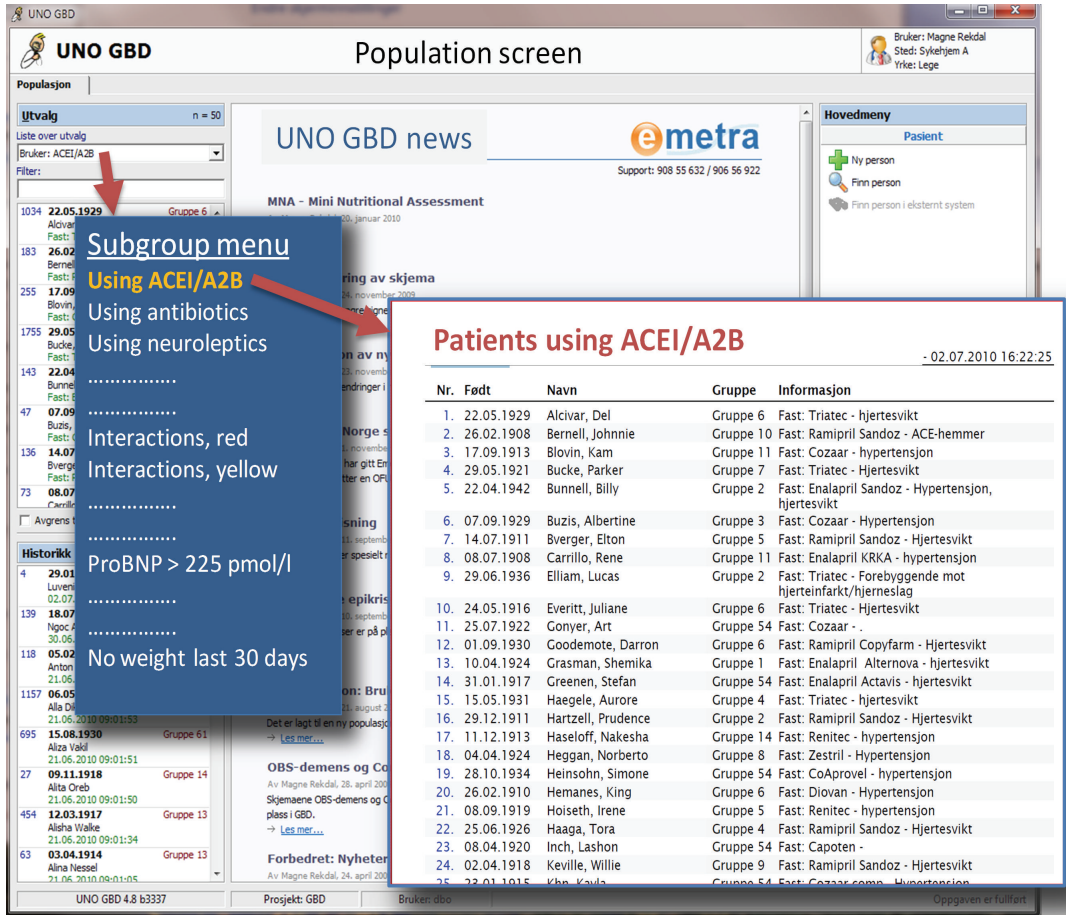


Figure 1: Population filters. How subgroup filters and reports are presented in the UNO GBD patient record system, a structured medical record system with decision-making support, tested in 7 nursing homes in Bergen, Norway 2008–2010. The blue "menu" is for translation purposes.

3.1. Before-Survey. In the prevalence study of 484 long-term patients ECG-ed, atrial fibrillation was found in 91 (18.8%). No significant differences existed between the 7 institutions. Of 91 atrial fibrillation patients, 14.2% were anticoagulated with warfarin, that is, 2.5% of all patients.

72.6% of all patients were not weighed for the last 30 days. There was an average of 121 days between weight measurements. Significant differences were demonstrated between nursing homes.

Of all patients, 24.4% were taking neuroleptics. 30.0% of the patients taking neuroleptics were on more than one drug.

3.2. Before—After. At the two institutions (E and F) participating in the before-after study, the proportion of patients taking neuroleptics was reduced from 33.0% to 21.5% (N = 183 before/205 after, chi-square test, P = 0.015), that is, a difference of 11.5% (95% CI: 2.3 to 20.6%). Warfarin increased from 3.0% to 9.8% (P = 0.013), that is, a difference of 6.8% (95% CI: 1.6 to 12.1%). Use of digitoxin did not increase significantly (8.0% versus 8.5%; P = 0.1), thyroxin was not reduced (10.0% versus 8.6%, P = 0.765), and antidiabetics did not increase (10.0% versus 10.5%; P = 0.996), Figure 4. The proportion of patients not weighed for the last 30 days was reduced from 72.6% to 16.0% (P < 0.001), that is, a difference of 56.6% (95% (CI: 47.5 to 64.5%).

The time-series for proportions of patients using neuroleptics is presented in Figure 3.

In the user survey (n = 272, 54%), 43% reported great or slightly better job satisfaction. Further results from the user survey are presented in Table 3.

4. Discussion

Endpoints changed significantly during intervention by increased use of warfarin, decreased use of neuroleptics, and a higher weighing rate. Job satisfaction was not adversely affected.

4.1. Limitations of the Study. The role of nursing homes in the delivery of social and health care services differs between, as well as within, countries. Nursing homes in many countries are managed as part of social care. In Norway, nursing homes are regulated as a health care service. These

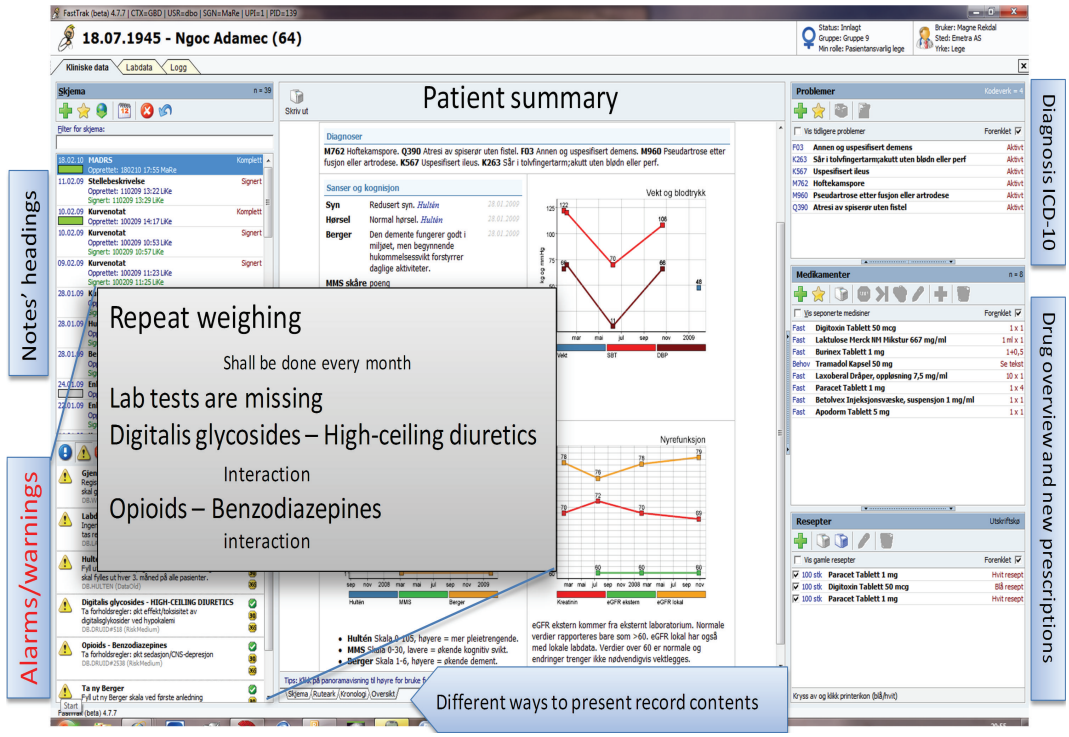


Figure 2: The way "reminders" and interaction warnings are presented in UNO GBD, a structured medical record system with decision-making support, tested in 7 nursing homes in Bergen, Norway 2008–2010. The grey "menu" is for translation purposes.

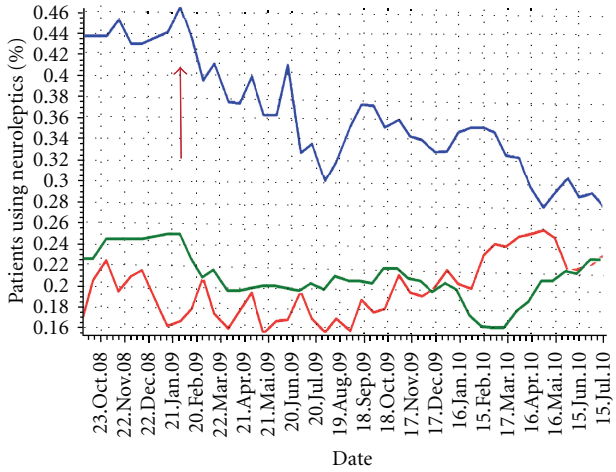


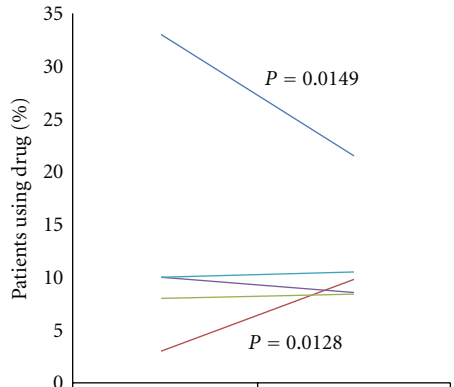
Figure 3: Time-series on the proportion of patients using neuroleptics, in 3 nursing homes in Bergen, Norway 2008–2010, before and during implementation with a structured medical record system with decision support. Blue line represents institution E (see Figure 1), green line institution F, and red line the developing institution. Institution E and F were included in the before-after study. Red arrow indicates implementation startup.

differences may influence the health issue landscape and composition of staff. Thus, comparisons and generalizations based on our findings should be made with care.

The methods for evaluating change and improvement strategies are not well described. Such study designs should generally be used in a context where they build on appropriate theoretical, qualitative, and modelling work, particularly in the development of appropriate interventions [29]. We feel that we have properly documented the fields in need of improvement and thus study objectives.

Baseline and follow-up data for the first cross-sectional sample were collected, by the prevalence study (before) and (in the case of the second sample) after the intervention, respectively. As it was not possible to collect follow-up data for everyone included in the first study (for political reasons) and the patients included in the second sample were not identical to those in the first due to deaths, the two samples were compared using methods for comparing unpaired data. This is a weakness, but to compensate for the 40% or so annual death rate in nursing homes, the sample size would have had to be much higher to be able to use patients as their own controls, and this may not have been advisable when testing front-end technology in the first study.

Our design must be seen in light of the immaturity of research in nursing homes in general. As far as we know, neither recent data exist on the prevalence of atrial fibrillation in a nursing home population and the use of warfarin, nor is information available on how well basic procedures like weighing are conducted. More information has been available on the use of neuroleptics. There was therefore a need to do a prevalence study, to define valid endpoints, and to do an intervention study. It may be claimed that we should have separated the tasks, but nursing homes are in great need of improvement strategies and time is short before the elderly wave is set to impact



	Before	After
% B01AA03	3	9.8
% C01AA	8	8.4
% H03AA01	10	8.6
% A10	10	10.5
% N05A	33	21.5

Figure 4: Changes in endpoints and internal controls in the before-after intervention study, among long-term patients in 2 nursing homes in Bergen, 2008–2010. Before and after intervention with a structured medical record with decision-making support, the proportion of patients on the drugs was measured ($N = 182$ before/205 after, chi-square test) Dark blue = Neuroleptics, red = warfarin, others = internal controls.

heavily on nursing home demands. Financial and political limitations played a role too, obstructing any possibility of performing a full-scale follow-up study. But conversely, it would have been a challenge, in a randomized trial within one municipality, albeit with 37 institutions to choose from, to avoid study group pollution and the "Hawthorne effect" [29, 30]. Starting out with a comprehensive and expensive randomized study would probably not have been ethical due to all the uncertainty and possible threats from new information technology systems, and hence probably difficult to fund. When we started, we did not know if it was possible to install the application, educate, and prepare for critical daily use in 7 institutions with 500 to 800 users within a timeframe of 4 months. Looking back, this may be regarded as the most convincing result of the project.

4.2. Effects of Integrated Electronic Decision Support. We used a design where we evaluated endpoints in a before-after study with internal controls [26–28]. The stability of internal controls throughout the intervention reinforces the internal validity of the study.

With the technology presented, effects can be measured continuously, Figure 3. However, we cannot conclude the extent to which the technical aspect or "awareness of the performance process" is responsible, through education, for the changes measured. Yet without any performance figures, it is not possible to focus on changing processes, so the two ways of influencing results are not independent factors.

The technology made it possible to monitor performance without time-consuming traditional studies and made performance feedback possible. This is a relatively new concept in medical research, made possible by structured medical input applicable to automatic and continuous analysis. Consequently, the proportion of patients taking neuroleptics could also be followed using time-series, giving more detailed information about the changing process and strengthening the validity of the effect results. As a critical information element, drugs were punched into each patient record at an early stage of the implementation process and this gave us a sufficient "before-point" on the time-series. We discovered that the significant change in the before-after study was due to only one of the participating institutions and that this institution showed up a clear brake in the curve at the point of intervention startup.

4.3. New Possibilities. We see from the time-series on neuroleptics (time-series are part of the patient record system) that the tool also provides a deeper understanding of the change process. By observing the curves, Figure 3, we learn something about possible variation in the use of neuroleptics during the year. This makes one think that performance feedback, over time, may equal performance around a "total average" [31]. Other authors have concluded that evaluative studies should report on usage patterns and progression of outcomes over time [32]. Very few authors have reported on feedback at institutional level with performance comparisons. At vaccination clinics, however, it has been shown that performance feedback at institutional level can improve quality [33]. Logically, this may be one way of influencing both generalized over- and undertreatment in institutions. Our own research (same material, and publications to come) has shown that differences between comparable nursing homes do exist, significantly. With regard to both the proportion of patients using cardiovascular and psychoactive medications, and weight loss and weighing routines, we found significant differences between the 7 nursing homes participating in the prevalence survey (same study, different publications). We hope to continue our research based on this feedback method to test if this is a way to increase equality and quality among a bigger number of institutions.

We are however convinced of the importance of human attention. Technology is a tool only, without any impact, if managers and practitioners are not reacting to warnings and are not exploiting the population filter function!

5. Conclusions

Statistics and management data can be continuously produced through daily bedside work. The structured electronic patient record system with decision support we tested can improve drug treatment and monitoring and better implementation of procedures. It can easily be installed for use in nursing homes. Controlled studies on a broader spectrum of clinical and administrative parameters should be performed.

Disclosure

K. Kruger will enjoy financial rights associated with the application tested, if commercialized.

Acknowledgments

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