The effects of an educational meeting and subsequent computer reminders on the ordering of laboratory tests by rheumatologists: an interrupted time series analysis

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Abstract

Objective

To examine the effects of an educational meeting and subsequent computer reminders on the number of ordered laboratory tests.

Methods

Using interrupted time series analysis we assessed whether trends in the number of laboratory tests ordered by rheumatologists between September 2012 and September 2015 at the Sint Maartenskliniek (the Netherlands) changed following an educational meeting (September 2013) and the introduction of computer reminders into the Computerised Physician Order Entry System (July 2014). The analyses were done for the set of tests on which both interventions had focussed (intervention tests; complement, cryoglobulins, immunoglobins, myeloma protein) and a set of control tests unrelated to the interventions (alanine transferase, anti-cyclic citrullinated peptide, C-reactive protein, creatine, haemoglobin, leukocytes, mean corpuscular volume, rheumatoid factor and thrombocytes).

Results

At the start of the study, 101 intervention tests and 7660 control tests were ordered per month by the rheumatologists. After the educational meeting, both the level and trend of ordered intervention and control tests did not change significantly. After implementation of the reminders, the level of ordered intervention tests decreased by 85.0 tests (95%-CI -133.3 to -36.8, p<0.01), the level of control tests did not change following the introduction of reminders.

Conclusion

In summary, an educational meeting alone was not effective in decreasing the number of ordered intervention tests, but the combination with computer reminders did result in a large decrease of those tests. Therefore, we recommend using computer reminders in addition to education if reduction of inappropriate test use is aimed for.

Key words

computer reminders, educational meeting, laboratory tests, rheumatology, interrupted time series design

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Received on February 7, 2016; accepted in revised form on July 4, 2016.

Competing interests: none declared.

Introduction

Excessive use of diagnostic laboratory tests is a major problem in healthcare and has recently been recognised as an important field for research (1). Not only does it constitute a waste of resources, it also results in an increased rate of false positives which may lead to further unnecessary testing, unnecessary treatment, and increased anxiety in both patients and physicians (1, 2). Still, many clinicians order irrelevant laboratory tests despite the available information about unnecessary test utilisation (2, 3).

A number of approaches have been used to reduce inappropriate testing using methods such as discouraging or not automatically fulfilling test orders, reducing availability of testing, giving feedback, raising awareness through education and the use of computer reminders (4).

Education, feedback and reminders are much used intervention strategies and although results differ between studies they have shown to be effective in different settings, including the reduction of unnecessary test orders (5–8).

A substantial proportion of diagnostic laboratory tests that were ordered at the Rheumatology Department of the study centre were tests that are not, or only very rarely, indicated for use in patients with a suspected rheumatic disease. This concerned the following tests: complement, cryoglobulins, immunoglobulins, myeloma protein (M protein) and anti-nuclear antibodies (ANA). These tests were all ordered relatively frequently, are expensive, and overuse could easily lead to false positives and associated over-treatment. Therefore, the aim of this study was to examine the effect of two interventions on the number of ordered tests. Of note, ANA testing has been subject to a specific intervention the results of which are described elsewhere and was therefore not included in this study (9).

Methods

Study design and setting

This is a controlled trial, using an interrupted time series design, on the effect of an educational meeting and subsequent introduction of computer reminders on the number of diagnostic tests ordered by 26 clinicians (15 rheumatologists, 7 residents, 4 physician assistants and nurse practitioners) from the Rheumatology Department at the Sint Maartenskliniek (specialised clinic for rheumatology, orthopaedics and rehabilitation medicine), the Netherlands.

As this was a quality improvement project performed by researchers working at the study centre, no formal ethical approval was needed. Furthermore, no informed consent of the patients was asked as no individual patient data were needed to assess the effectiveness of the interventions.

Interventions

An educational meeting regarding the intervention tests (complement, cryoglobulins, immunoglobulins and M protein; Table I) took place in September 2013. This meeting consisted of a 1-hour educational meeting, presented by two experienced medical immunologists working at the external laboratory where the intervention tests were performed. During the meeting background information on the intervention tests was provided and the rare indications in daily rheumatology practice for these tests were explained. Clinicians were advised not to order test tests unless specific signs or symptoms were present. At the time of the educational meeting 26 clinicians (15 rheumatologists, 4 physician assistants and 7 residents) were working at the Rheumatology Department, all were invited for the meeting.

In July 2014 computer reminders were incorporated into the Computerised Physician Order Entry (CPOE) system, which is linked to the Electronic Health Record (EHR) used at the study centre (EZIS 5.2, Chipsoft). The reminders functioned as follows: whenever a clinician tried to order one of the intervention tests a pop-up message appeared explaining in which specific rheumatology-related situation the test was indicated or not (Table I). If clinicians still wanted to order the test, a text field was shown asking the reason for ordering the test. The intervention tests could only be ordered if a rea-

son was entered although there was no check as to whether the reason was valid. Both the educational meeting and the computer reminders were available for all clinicians ordering laboratory tests at the Rheumatology Department. The development of the reminders was a collaboration between the laboratory and Rheumatology Department.
The content of each reminder was created by 3 rheumatologists, including an expert on systemic diseases and the coordinator of the laboratory.

Outcome measures and data collection
The primary outcome of this study was the number of intervention and control tests ordered by clinicians working at the study clinic. Data on the outcomes are measured at equally spaced (monthly) intervals over the study period (September 2012 to September 2015). The control tests were a set of simple routine tests at which no intervention was targeted (Table I). These were included to control for time trends in clinicians' ordering behaviour that were unrelated to the interventions.
Secondary outcomes were the percentage of abnormal intervention test results and the percentage of valid reasons provided with the intervention test orders after implementation of the reminders, as judged by two experts.
Data on the number of intervention and control tests ordered by included clinicians were collected retrospectively using the local laboratory database. Data was collected for the twelve months before any intervention (pre-intervention period; September 2012 to September 2013), 10 months after the educational meeting but before implementation of the computer reminders (post-intervention period 1; September 2013 to July 2014), and the 14 months after computer reminders were implemented (post-intervention period 2; July 2014 to September 2015).

Data analysis
Statistical analyses were performed using STATA v. 13.1. Depending on the type of variable, descriptive statistics are presented as percentages with the accompanying absolute numbers or as means.

Table I. Intervention and control tests used in this study.

Intervention tests	Pop-up text
Complement 3 (C3) Complement 4 (C4)	There is no indication within rheumatology for complement testing. One exception is C3 testing in the follow up of systemic lupus erythematosus to assess the risk of nephritis or neuro-psychiatric systemic lupus erythematosus although the evidence is limited. When clinical signs of complement deficiency disease are present, do not test for complement but refer to the internal medicine department.
Cryoglobulins	Cryoglobulins testing is only indicated in cutaneous vasculitis and/or mononeuritis, and when there are signs of hyperviscosity syndrome.
Immunoglobulin A (IgA) Immunoglobulin G (IgG) Immunoglobulin M (IgM)	There is no indication within rheumatology for measurement of immunoglobulins. There is a limited association with the presence of a rheumatic disease, and abnormal results have no clinical consequences. Only in the analysis of recurring infections and when monitoring gamma globulin therapy, testing is recommended.
M protein	There is no indication within rheumatology for assessment of monoclonal gammopathy. In case of a suspected haematologic malignancy referral to the haematology or internal medicine department is necessary, independent of a M protein result. Therefore, testing by rheumatologists is not needed
Control tests	
Alanine transaminase (ALT)	Leukocytes
Anti-cyclic citrullinated peptide (anti-CCP)	Mean corpuscular volume (MCV)
C-reactive protein (CRP)	Rheumatoid factor (RF)
Creatine	Thrombocytes
Haemoglobin	

To assess the impact of the two interventions on the numbers of tests ordered segmented regression analysis of interrupted time series analysis (ITSA) was used. Using ITSA we were able to detect whether or not our interventions had a significantly greater effect than any underlying secular trend (10). The segmented linear regression models included two change points (education and reminders) in order to estimate changes in the level and trend of the number of ordered tests after the change points. Separate regression models were run for the intervention and control test data. Sensitivity analyses assessing the impact of possible autocorrelation between measurements of consecutive months were performed. Of note, due to the order of implementation of the interventions, the effect of education is relative to the pre-invention period and the estimated effect of reminders is the additional effect of reminders on top of the educational intervention. Results are reported as regression coefficients (level and trend) with the corresponding 95% confidence interval (95% CI) and *p*-value.
A chi square test was used to compare the number of abnormal results over the three periods. Outcomes were defined as statistical significant if $p<0.05$.

Results

23 out of the 26 clinicians attended the educational meeting (15 out of 15 rheumatologists, all 4 of the physician assistants and 4 out of 7 residents), which was received positively and discussed critically.
At the start of the pre-intervention period 101 intervention tests were ordered per month (level) and during the pre-intervention period the number of ordered intervention tests increased with 2.8 test per month (non-significant; trend). After the educational meeting the number of intervention tests ordered remained stable, with no significant changes in level or trend. After implementation of the reminders, the level of ordered intervention tests decreased significantly by 85.0 tests (95%-CI -133.3 to -36.8, $p<0.01$) although the difference in trend was non-significant (1.06, 95%-CI -6.2 to 8.3, $p=0.77$). With regard to the control tests, 7660 tests were ordered at

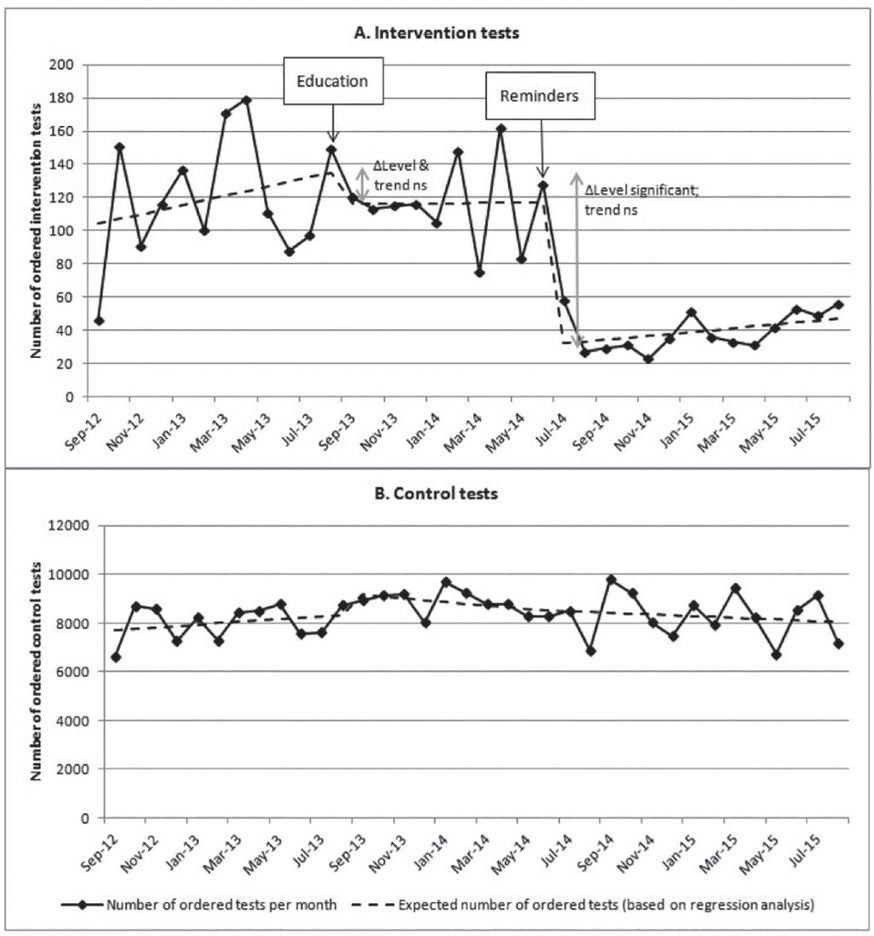

Fig. 1. Number of intervention and control test orders per month.

the start of the pre-intervention period. None of the two interventions resulted in a significant change in either the level or the trend of ordered control tests. The results are also graphically depicted in Figure 1.

In the analysis of intervention and of control test, the autocorrelation function and the Durbin-Watson tests (up to order 10) showed little indication of autocorrelation between consecutive months. Sensitivity analyses modelling autocorrelation (up to order 10) were performed. These did not substantially improve fit and led to the same conclusion for the interventions.

Similar to the numbers of intervention tests ordered, the percentage of abnormal test results did not change (pre-intervention period 17.7% and 17.4% after the educational meeting, p=0.83). Comparable results were obtained for the period following the reminders with the percentage of abnormal intervention test results being 18.4% (p= 0.73). Finally, all intervention tests ordered after the implementation of the reminders included a clearly worded reason. However, only 34% of those reasons were judged to be valid. In addition, this did not make any difference regarding the percentage of abnormal test results in this subgroup with 18.8% being abnormal (p=0.89).

Discussion

In this study we observed that an educational meeting alone was not effective, however addition of targeted computer reminders did give a substantial decrease in the number of orders for intervention tests while the number of control test orders did not change.

The strengths of our study are the use of an interrupted time series design, the inclusion of control tests and the stepwise independent use of two different and relatively simple interventions. However, some limitations are also present. Firstly, the educational meeting and the implementation of computer reminders were available to all clinicians, meaning that after implementation we did not have a control group of intervention tests without being subject to the intervention. However, we did include a selection of routine laboratory tests as a control group to see whether a change in the number of intervention tests ordered could be caused by an overall change in test ordering behaviour. Secondly, when only looking at the intervention tests, we are not able to infer a definite causal relation between our intervention and the results afterwards because other events in the same time period might have attributed to the observed results. However, as no changes were observed in the number of ordered control tests after the implementation of the computer reminders, it is very unlikely that another event in the same time period caused the observed decrease in the number of intervention tests. Furthermore, the number of patients seen at the study clinic was relatively stable over the full study period (data not shown), excluding this as a reason for the observed results. Finally, a steady increase in the number of ordered intervention tests is visible near the end of the observation period. Although the difference in trend between the pre-intervention period and the period after intervention 2 was non-significant, the increase may continue past the end of this study. Therefore we plan to replicate our analysis in the future to extend our current follow-up period.

The lack of effect from the educational meeting alone in our study corresponds with previous research suggesting that education is a necessary but on its own insufficient intervention to reduce test ordering. Strengthening this conclusion is the fact that nearly all of the departments' clinicians (23 out of 26) attended the educational meeting, meaning that the lack of effect from the educational meeting is not likely to be a result of a lack of attendance. A factor that could explain the lack of effect from the educational meeting is that it was provided by two immunologists from another hospital. This may have reduced the acceptance as one of our

previous studies regarding a similar intervention showed that a familiar intervention team was an important factor for clinicians in changing their ordering behaviour (11). Furthermore, our study confirms previous observations that education has a stronger effect when combined with other interventions (4, 12). In addition, the effect of the computer reminders corresponds to other studies. These studies also found the reminders to be effective, although this usually concerned smaller effects than observed in our study (5).

Other than the combination between education and computer reminders, three other factors are likely to have contributed to the effect of reminders observed in our study. Firstly, previous studies have shown that reminders are more successful if they interrupt in the practitioner's routine and are delivered at the time of decision making (13). Both factors were incorporated with our reminder system, as reminders were shown directly after selecting one of the intervention tests in the CPOE system. Secondly, the intervention tests in this study were not ordered very frequently, even before any intervention. This means that the risk of pop-up fatigue, a weakness of computer reminders where overly frequent pop-ups get ignored after some time, was limited (12, 14). However, pop-up fatigue may not have been completely avoided as the number of ordered intervention tests is slowly increasing again near the end of the study period. Thirdly, the pop-up text was created in collaboration by 3 of the department's rheumatologists and a laboratory coordinator, which may have increased the acceptance of the pop-ups compared to a situation where someone from outside the clinic was responsible for the pop-ups.

In addition to the number of tests ordered, we also assessed the percentage of abnormal test results. One would expect that a reduction in the number of unnecessary tests would also increase the proportion of correctly ordered tests and therefore an increase in the percentage of abnormal results. Contrary to this, the percentage of abnormal test results did not change, which may seem counterintuitive. However, this can be explained by the observation that only 34% of the reasons provided with the intervention test orders were valid, making it likely that patient selection by clinicians is still suboptimal. This is further supported by the fact that the percentage of abnormal test results did not differ between the intervention tests ordered with a valid reason and those without one, which means that a higher percentage of correctly ordered tests would not necessarily increase the percentage of abnormal results. This lack of difference in the percentage of abnormal results could indicate that even for patients with a valid reason for testing the test may not be useful in the majority of patients. In other words, overuse of intervention tests by clinicians is still present, although to a lesser extent than before the interventions.

In summary, the educational meeting alone was not effective in decreasing the number of ordered intervention tests, but the combination with computer reminders did result in a large decrease of those tests. Therefore, we recommend using computer reminders in addition to education if reduction of inappropriate test use is aimed for.

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