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ORIGINAL ARTICLE

Blood pressure recording bias during a period when the Quality and Outcomes Framework was introduced

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The 2004 UK Quality and Outcomes Framework (QOF) remunerates general practitioners for achieving a target blood pressure (BP) of ⩽150/90 mm Hg for patients with ischaemic heart disease, stroke and hypertension. Using the DIN-LINK GP database, we investigated whether introducing the target altered BP recording. We extracted 3 164 189 BP measurements from 236 467 patients, with the above diagnoses from 2000 to 2005. Treatment was assessed by Read codes indicating prescriptions for antihypertensive drugs. Over this period, recorded systolic BP (SBP) fell: 36% had an SBP >150 mm Hg in 2000–2001, and only 19% in 2004–2005. However, there was a trend towards recording systolic values just below, rather than just above the 150 cut-off. In 2000–2001, 2.3% of patients had 148–149 recorded and 1.8% had 151–152. In 2004–2005, the figures were 4.2 and 1.3%, respectively. By smoothing the distribution we estimate that the true percentage of patients with SBP>150 mm Hg in 2004–2005 was 23%, rather than the 19% recorded. Moreover, patients with a recorded SBP=148–149 were more likely to have a recorded diastolic BP⩽90 (93%) than patients with SBP=151–152 (78%). However, patients just below the 150 mm Hg cut-off received more antihypertensive treatment than those just above it (odds ratio=1.20, 95% confidence interval 1.01–1.41). We conclude that blood pressure levels in UK primary care have continued to fall through the introduction of QOF, offering significant public health benefits in the future. This fall has been exaggerated due to values being clustered just below the QOF target, but there is no evidence of adverse effects of this on clinical management.
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Introduction

The UK Quality and Outcomes Framework (QOF) was introduced in 2004,[1] aiming to improve chronic disease management; it remunerates general practitioners for achieving clinical targets. It is an approach that has attracted considerable international interest.[2] Blood pressure (BP) control is important for several chronic diseases and the audit target set for patients with ischaemic heart disease, stroke and hypertension by QOF is 150 mm Hg systolic or less and 90 mm Hg diastolic or less. This is an audit target, and it is recognized that targets in clinical practice should often be lower than this.[3]

The setting of targets for BP and other clinical areas has been shown to have unintended consequences. In the Syst-Eur Trial, measurement number preference at just below a target systolic BP (SBP) of 150 mm Hg was shown throughout the trial.[4] We have shown earlier that an unintended consequence of the QOF was an apparent fall in the incidence of ischaemic heart disease in a UK General Practice population, due in part to disease register cleaning.[5] Other authors have raised concerns that QOF may distort priorities, and that conditions that are not part of QOF may be managed with less care, as a consequence.[6]

In this paper, we investigate whether the introduction of QOF targets led to any alteration in BP recording over the period 2000–2005. Specifically, we wished to determine whether digit preference at just below the target level had appeared and, if so, whether this was associated with evidence of different treatments from those patients with BP readings just above the QOF targets.

To assess possible QOF effects, we focused on the 150/90 mm Hg BP cut-off in cardiovascular disease (CVD) patients. Greater attention was paid to the 150 systolic cut-off (rather than the 90 mm Hg diastolic target), as this represented a new target introduced by QOF. A diastolic target of 90 mm Hg predates the introduction of QOF[7] and we were interested in whether the new 150 target influenced the recording of diastolic BP (DBP). We also examined recording around systolic values of 140 and 160 to assess

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whether any phenomena observed around 150 were also seen around these values.

Materials and methods

DIN-LINK is an anonymized computerized UK primary care database from practices that use iSOFT (formerly Torex) software (iSOFT Group plc, Manchester, UK). We have outlined earlier methods for identifying good-quality data in DIN-LINK[8] and this approach was repeated with further updates of the database. Validations of the DIN-LINK database have shown that its age–gender population structure is highly comparable with another large primary care database (the General Practice Research Database),[8] and we have shown that prevalence rates for a wide range of conditions including ischaemic heart disease (IHD),[8] diabetes,[9] atrial fibrillation[10] and common childhood diagnoses[11] are similar to other published data. This report is based on 152 practices that contributed continuous high-quality data[8] between 2000 and 2005 (pre- and post-dating the introduction of QOF).

We extracted all SBP and DBP measurements made during this time. After minor data cleaning (for example, excluding pairs with a missing or nonsense value, or swapping the diastolic and systolic values that had been entered the wrong way round), there were 6 275 796 pairs of BP measurements made on 949 540 patients. Our analyses focus on 3 164 189 blood pressure recordings made on 182 614 patients with a Read code for stroke/IHD/hypertension ('CVD' patients), in their record at the time of blood pressure measurement.

We present histograms of the distribution of SBP recording for two distinct periods, pre- and post-QOF (2000–2001 and 2004–2005). The QOF system works nationally by uploading data, such as BP measurements, from individual practices to a national database. This is for the purpose of calculating performance and associated remuneration, and occurs at the end of March each year. QOF target assessment is based on the most recent blood pressure recording at the time of upload. The histograms are therefore based on the last measurement for each patient before the March upload each year ($n = 116\,379$ in 2000–2001 and 177 015 in 2004–2005).

To assess the effect of digit preference, we calculated a crude 'expected' value for each integer increment in BP based on a moving average around the integer, encompassing all possible end digits. For the integer to lie in the middle of the span, the range includes 11 units, but only assigns half weight to the two end points. For example, for 152, we would take the average of the span of 147–157, allocating only half weight to 147 and 157.

As systolic and diastolic targets are linked in QOF, we also examined the degree to which the level of SBP influenced the likelihood of achieving a DBP of 90 or less, and whether there was any change in this influence over time. We plotted the proportion of patients achieving a DBP of 90 or less by SBP for the periods 2000–2001 and 2004–2005.

We also present monthly time-series plots between January 2000 and December 2005 of the percentage of SBP recordings in each month ± 2 mm Hg around 140, 150 and 160 mm Hg. These plots are based on monthly counts of all recordings for patients with CVD at the time of measurement. The number of measurements (patients) per year rose: 2000 = 356 500 (112 344), 2001 = 420 278 (126 912), 2002 = 480 950 (140 238), 2003 = 549 822 (173 555), 2004 = 679 994 (173 555) and 2005 = 676 645 (179 015).

Treatment for hypertension was assessed by electronically searching for Read codes indicating prescriptions for any antihypertensive drugs (British National Formulary categories: 2.6.2. and 2.5. except 2.5.5.1 and 2.5.5.2) in the first 3 months of 2005.

Finally, we examined variation between practices in 2004–2005, by classifying them according to the degree to which they tended to record just under the 150 mm Hg threshold as opposed to above. For each practice, we calculated the proportion of measurements recorded as 148 or 149 out of all those in the following set: 148, 149, 151 or 152. Practices with less than 20 such observations were excluded ($n = 18$). Spearman's rank correlation coefficient was used to assess the association between prevalence of antihypertensive therapy and preference for 148/149 vs 151/152.

Results

Trend in SBP

Over the study period, there was a steady fall in SBP. The distributions of SBP values in the 2000–2001 and 2004–2005 QOF years are shown in Figure 1 for stroke/ischaemic heart disease/hypertension patients. The coloured bars highlight values up to ± 2 mm Hg around 140, 150 and 160 mm Hg. In 2000–2001, 36% of patients had an SBP of over 150 mm Hg compared with 19% in 2004–2005. Percentages were similar when restricted to patients with measurements in both periods (data not shown).

Systolic BP values for patients with multiple measurements in the QOF period were on average lower for the final measurement in the period. For example, patients with at least two measurements in the period ($n = 82\,080$ in 2001 and $n = 142\,448$ in 2005) had a lower final mean SBP compared with the penultimate measurement (a mean difference of 2.5 mm Hg in 2001 and 3.1 mm Hg in 2005).

Trend in digit preference

In both years, typical patterns of digit preference were seen: values with a terminal zero were very

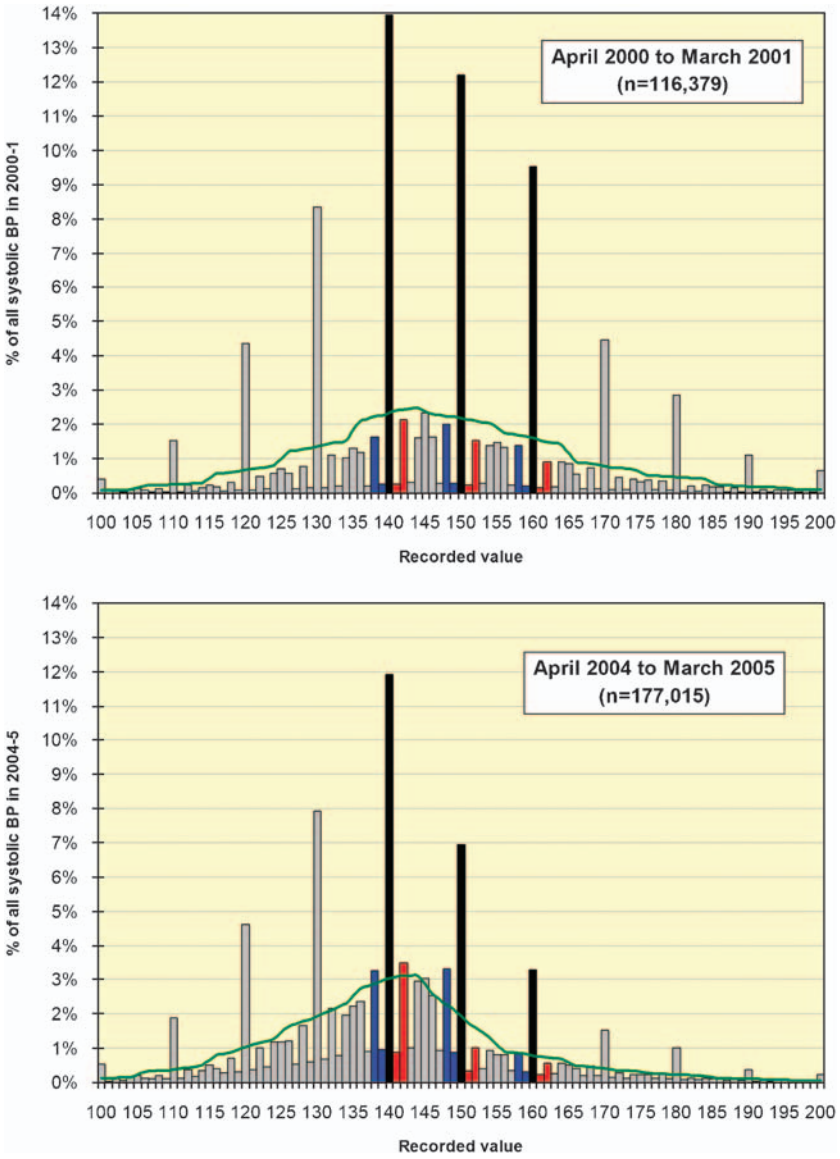

Figure 1 Distribution of recorded systolic blood pressure in the periods April 2000 to March 2001 and April 2004 to March 2005 among patients with CVD (IHD/stroke/hypertension). Black bars (140, 150 and 160), blue bars (138/139, 148/149 and 158/159) and red bars (141/142, 151/152 and 161/162). Green line represents expected values calculated from a 10-unit 'moving average'.

much more frequent than other values, but terminal zero preference declined markedly from 60% in 2000–2001 to 41% in 2004–2005. Even terminal digits were more frequent than odd, again less so in 2004–2005 (Figure 1).

Over the study period, there was a relative increase in the recording of systolic values of 148–149 compared with 151–152. By 2004–2005, patients were more than three times more likely to have 148–149 (4.2%) recorded than 151–152 (1.3%); in 2000–2001, the percentages were 2.3 and 1.8%, respectively. By 2004–2005, 148 is recorded above our calculation of expected values whereas 152 is clearly below (Figure 1). Overall, the 'expected' percentages suggest that 23% of patients should have had a recorded SBP of >150 mm Hg in 2004–2005 (compared with 19% actually recorded).

Figure 2 documents this trend further, plotting the monthly percentage of recorded SBP ±2 mm Hg around 140, 150 and 160 mm Hg. A different pattern emerged for each: for values around 140, 141/142 occurred slightly more frequently than 138/139 until about the end of 2003, after which they occurred with similar frequency. For values around 150, 148/149 consistently occurred more frequently than 151/152, but after the end of 2003, this difference increased markedly, the divergence representing a two-fold disparity by 2005. For values around 160, 158/159 consistently occurred slightly more frequently than 161/162.

A pattern, similar to that seen in Figure 2, although less marked, was seen for recordings of DBPs. From around 2004, there was a trend of divergence with recordings just below 90 occurring

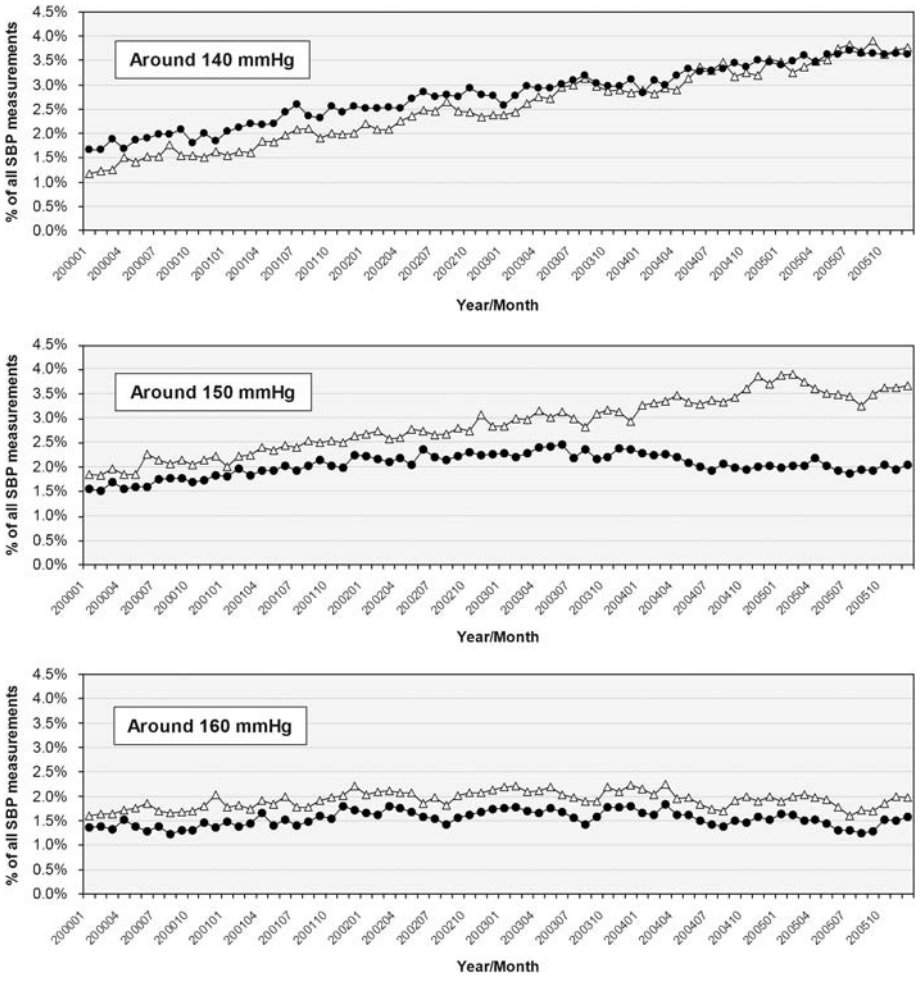

Figure 2 Monthly percentage of systolic blood pressure readings recorded immediately below and above 140, 150 and 160 mm Hg among patients with CVD (IHD/stroke/hypertension): Jan 2000 to Dec 2005. White triangles = 138/139 (top), 148/149 (middle) and 158/159 (bottom). Black circles = 141/142 (top), 151/152 (middle) and 161/162 (bottom).

increasingly more frequently than recordings just above 90 (data not shown).

Figure 3 plots the proportion of patients with a DBP of 90 or less by SBP. As might be expected, this proportion fell as SBP increased. However, this pattern differed between years. In 2000–2001, the decrease was steady, but in 2004–2005, there was a noticeable 'step' down around the value of 150. Here the percentages with a diastolic of 90 or less were similar in those with an SBP of 148–149 (93%) and 150 (92%), but much lower in patients with an SBP of 151–152 (78%).

Antihypertensive medication

Treatment rates in 2004–2005 of CVD patients with a last SBP in the QOF period of 148–149 ($n = 7428$) were compared with those with 151–152 ($n = 2352$). Both groups were generally prescribed some form of antihypertensive medication (86.1 vs 84.2%, respectively), with patients just below the 150 mm Hg target more likely to receive treatment (odds ratio = 1.10, 95% confidence interval 1.00–1.20). A similar observation was made at practice level: for 134 practices with sufficient measurements, a practice's preference rate for 148/149 (over 151/152) vs its treatment rate for all CVD patients showed a weak positive association (Spearman's rank coefficient $r = 0.04$, $P = 0.02$) in 2004–2005.

Exception reporting

Exception reporting did not exist in 2001 pre-QOF, but by 2005, 3% of hypertensive subjects were so labelled. Excluding such subjects would have artificially exaggerated the fall in blood pressure, as exception-reported subjects had blood pressures on average 2.6 mm Hg higher than subjects not exception reported. Unsurprisingly, the prevalence of exception reporting was higher for readings >150 mm Hg systolic (5.2%) than for those that are equal or below (2.8%).

Discussion

Principal findings

The recorded prevalence of systolic readings above 150 mm Hg in CVD patients fell from 36%

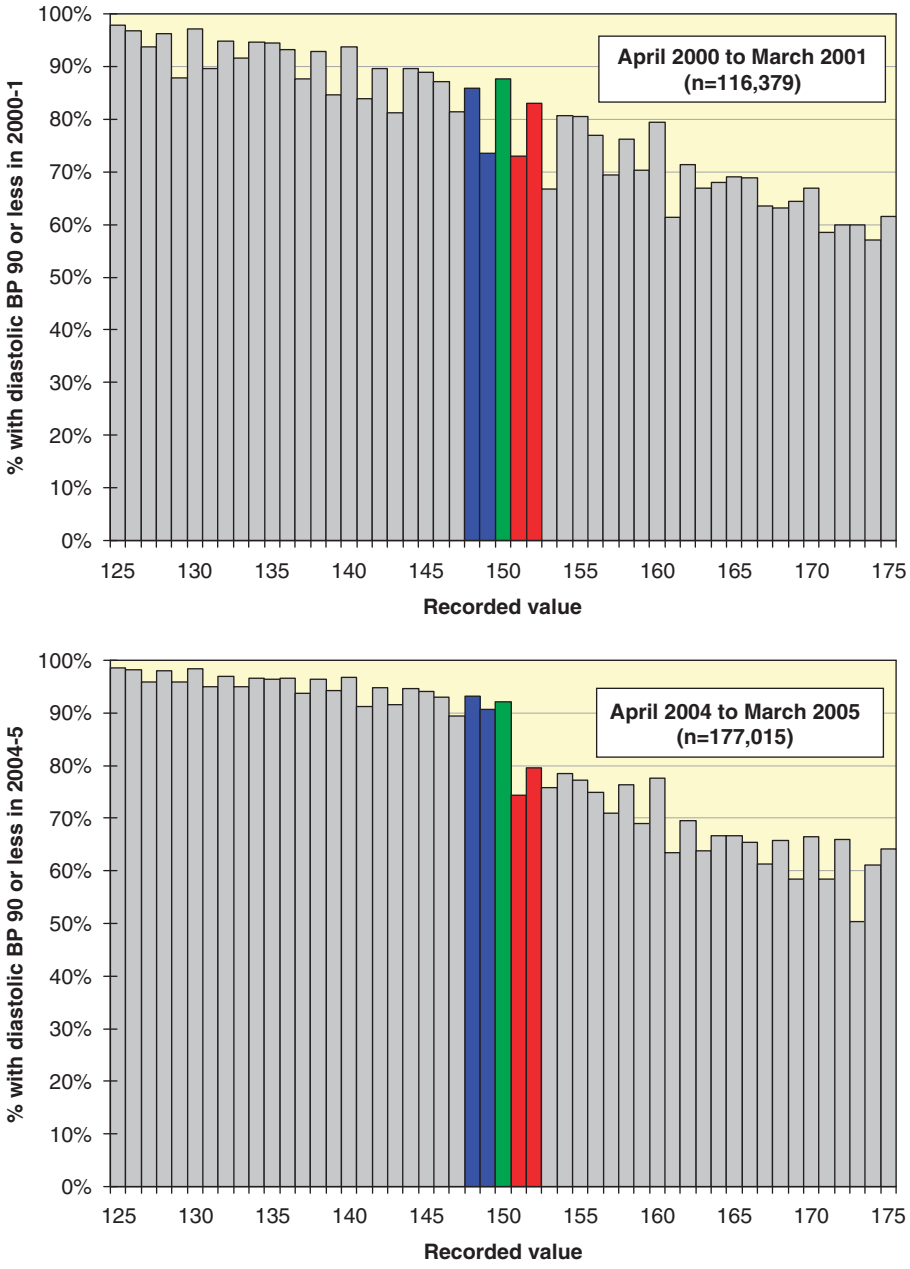

Figure 3 Percentage of patients with a diastolic blood pressure <90 mm Hg stratified by their systolic blood pressure (125–175 mm Hg), in the periods April 2000 to March 2001 and April 2004 to March 2005 among patients with CVD (IHD/stroke/hypertension). Blue bars represent SBP = 148-9, green bar represents SBP = 150, red bars represent SBP = 151-2.

in 2000–2001 to 19% in 2004–2005, a time period in which a QOF target of 150/190 or less was introduced. Digit preference was marked, especially terminal zero preference, but this declined over the study period. Over this time, we observed a relative increase in the recording of systolic values of 148/149 compared with that of 151/152. We estimate that this recording bias reduced the prevalence of SBP above 150 mm Hg from 23% to the recorded 19% in 2005; however, this represents only a small part of the overall fall in systolic hypertension between 2000–2001 and 2004–2005. Importantly, this recording bias was not associated with any adverse effect on patient treatment.

Falling blood pressure levels

Our analysis of recording bias took place against a background of falling blood pressure levels, and it is important to consider other potential explanations for this fall. A long-term trend of steadily falling BP levels has been observed in Health Survey for England data for a sample of the general population,[12] but the fall observed here is greater. Possible

explanations include (i) better treatment; (ii) a change in the population being measured, with increasing numbers of less hypertensive patients having their measurements recorded; (iii) a change in machines used for measuring blood pressure; and (iv) bias, by which patients with blood pressure just above 150 mm Hg have it recorded just below.

The prevalence of treatment with antihypertensives in CVD patients rose from 80.0% in 2000–2001 to 86.1% in 2004–2005 among CVD patients. The fact that the fall in BP levels remained when analysis was restricted to patients with recordings in both periods, suggests that better treatment of hypertensive patients is a more plausible reason for this trend, rather than a changing population in whom blood pressure was being measured.[13] The QOF may have had a beneficial effect here, and our findings support a recent observation that the decline in BP levels may have been accelerated by the introduction of QOF.[14]

Digit preference has often been noted in studies of BP recording.[15] However, semi-automated blood pressure measuring devices have been introduced in general practice in the past 5 years[16] and are likely to have a significantly reduced terminal digit preference.[17,18] Unfortunately, we do not know how widely general practitioners have moved to using semi-automated devices. We noted a marked reduction in digit preference during the study, with terminal zero preference falling from 60 to 41% of recordings for systolic measures over the period, presumably explained by the introduction of semi-automated devices. However, it seems unlikely that such changes have played a major role in the downward shift in blood pressure. First, the data from the Health Survey for England emphasize that a real fall in blood pressure has occurred over this period. Second, a study in UK primary care showed that the introduction of semi-automated devices did not appear to lead to changes in recorded mean BP.[17]

We estimate that this bias means that the prevalence of systolic pressures above 150 mm Hg will have been underestimated by 4 percentage points in 2004/2005; that is, the true prevalence of systolic pressures above 150 mm Hg was 23% rather than the 19% recorded. It seems likely that this bias is a consequence of the introduction of the QOF target of 150/90 as it became apparent in the preparatory period before the introduction of QOF targets, and is not seen for values that are not related to the QOF targets. We also noted an association between recording SBPs and DBPs just below the target levels, which adds weight to the suggestion that this bias is directly attributable to the 150/90 target. We observed that the final BP measurement in the QOF period was on average lower than the penultimate measurement in the period. However, as this phenomenon was seen in 2001 (pre-QOF) as well as in 2005, we therefore think that it is largely due to the consistent fall over time in levels rather than as a consequence of QOF.

Strengths and weaknesses

This study's strengths lie in its use of a large and representative sample of UK primary care patients. A weakness is that we were unable to assess the effect of changes in methods of BP measurement over the study period. We were also unable to gain any insight into the process that determines the measurement entered on the system, one possible method being, for instance, the lowest of the three readings made on that day.[19] This highlights a weakness of QOF, as no guidelines are given with the targets to standardize the measurement process. A recent paper illustrated how the percentage of patients achieving a BP target within a single practice varies according to the method of measurement.[19]

A further limitation is that the QOF target for SBP includes 150 mm Hg in its range. We were not able to assess whether there was any increased recording of 150 compared with 152, as might be predicted from the above. This is because the magnitudes of the terminal zero preference effects, which also varied during the study period, obscure any smaller effects of recording bias due to other causes.

Finally, we chose to keep patients who are excluded from QOF (so-called 'Exception Reporting') in the analysis for 2005. As QOF did not exist in 2001, we did not wish to only exclude patients in the later group, as this would introduce bias. Indeed, it would tend to artificially exaggerate the fall in blood pressure.

Clinical consequences

It is important to assess if there were clinical consequences associated with recording values below rather than above 150 mm Hg. If some patients with BP recordings just below the target were misclassified, we would be concerned if they were showing lower treatment rates than those above the target. However, the contrary was observed, and those with a recorded value of 148-9 were marginally more likely to be on antihypertensive therapy. Our data do not, therefore, support any suggestion that the divergent trend in the recording of BP around the QOF target has led to undertreatment of patients classified as having lower BP. This contrasts with the finding of the General Practice Hypertension Study Group, which found an excess mortality in female subjects with a DBP value recorded as 88–89, where the target value was 90 mm Hg.[20]

Also, we did not find that the degree to which practices appeared to have been influenced by the QOF targets had any substantive effect on the way in which they treated their hypertensive patients. This is again reassuring and contrasts with a recent US study,[21] that showed that practices with higher levels of overall digit preference had lower average SBP levels and were less likely to treat their patients.

We conclude that BP levels have decreased in the population, and that QOF targets may have contributed to this through increased treatment. Since the introduction of QOF, this fall may be slightly over-estimated by systematic biases in the recording of BP just below the target, an unintended effect of QOF with potential epidemiological consequences. As there is considerable international interest in the utility and effects of QOF,[2] this is an important observation, but it should not distract from the significant public health benefits that will result from a continuing fall in population blood pressure levels.

What is known about the topic

- BP measurement number preference is a demonstrated consequence of target setting.
- Some studies have shown that BP number preference adversely affects treatment of patients.
- The UK General Practice Quality and Outcomes Framework has influenced recording of trends in ischaemic heart disease.

What this study adds

- BP levels in UK primary care have continued to fall during the introduction of QOF, offering significant public health benefits in the future.
- This fall has been exaggerated due to increased number preference for values just below the QOF target. The true prevalence of systolic BP >150 mm Hg in 2004–2005 may be around 4% higher than recorded data suggest.
- There was no evidence of adverse effects of this recording bias on clinical management.

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