



Identifying pathways from quality of care to outcomes and satisfaction in Primary Care using structural equation modelling

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**Identifying pathways from quality of care to outcomes and satisfaction in
Primary Care using structural equation modelling**

For Peer Review

ABSTRACT

Objective: To study the relationships between the different domains of quality of primary healthcare for the evaluation of health system performance and informing policy decision making.

Data Sources: 137 quality indicators collected from 7,607 English practices between 2011-2012.

Study design: Cross-sectional study at the practice level. Indicators were allocated to sub-domains of processes of care (“quality assurance”, “education and training”, “medicines management”, “access”, “clinical management” and “patient-centered care”), health outcomes (“intermediate outcomes” and “patient-reported health status”) and patient satisfaction. The relationships between the sub-domains were hypothesized in a conceptual model and subsequently tested using structural equation modelling.

Principal Findings: The model supported two independent paths. In the first path, “access” was associated with “patient-centered care” ($\beta=0.63$), which in turn was strongly associated with “patient satisfaction” ($\beta=0.88$). In the second path, “education and training” was associated with “clinical management” ($\beta=0.32$), which in turn was associated with “intermediate outcomes” ($\beta=0.69$). “Patient-reported health status” was weakly associated with “patient-centered care” ($\beta=-0.05$), and “patient satisfaction” ($\beta=0.09$), and not associated with “clinical management” or “intermediate outcomes”.

Conclusions: This is the first empirical model to simultaneously provide evidence on the independence of all intermediate health care outcomes, patient satisfaction, and health status. The explanatory paths via technical quality clinical management and patient centeredness offer specific opportunities for the development of quality improvement initiatives.

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Key words: Primary Health Care; clinical quality; health care; patient experience; quality indicators; quality of health care; technical quality of care.

For Peer Review

BACKGROUND

Providing high-quality clinical care is a clear priority for most healthcare systems (Kocher, Emanuel, and DeParle 2010). There is a general agreement that quality of care is a complex and multidimensional construct (Donabedian 1980; Steffen 1988; Lohr, Donaldson and Harris-Wehling 1992; Bull 1994; Winefield, Murrell, and Clifford 1995; Evans et al. 2001; Harteloh 2003; Howie, Heaney, and Maxwell 2004; Cooperberg, Birkmeyer, and Litwin 2009; Gardner and Mazza 2012). One commonly accepted definition conceptualizes the quality of health care as to whether individuals can access the health structures and processes of care which they need and whether the care received is effective, thereby focusing on the domains of access and effectiveness (Campbell, Roland, and Buetow 2000). There is substantial variation in the domains proposed in the different definitions and, not surprisingly, a range of approaches have been used to measure quality of care focusing on efficiency, technical quality, patient centeredness, patient satisfaction, or health outcomes, among other (Goodwin et al. 2011).

Understanding the nature of the potential associations between these different domains of healthcare quality, and how they can help predict health outcomes has important implications for research (e.g. to inform the choice of measures) and healthcare configuration (e.g. to inform resource allocation). This issue has been the focus of a substantial number of studies. Some of them have examined the association between the quality of technical aspects of clinical care and patient satisfaction (Safran et al. 1998; Schneider et al. 2001; Gandhi et al. 2002; Chang et al. 2006; Rao et al. 2006; Sequist et al. 2008; Fenton et al. 2012; Llanwarne et al. 2013). Other studies have examined the relationship between access to healthcare and patient satisfaction (Kontopantelis, Roland and Reeves, 2010), between quality of care and health outcomes (Mold et al. 2011), between patient centeredness and satisfaction (Kinnersley et al. 1999; Paddison et al. 2015), between patient centeredness and

health outcomes (Kinnersley 1999; Shi et al. 2002), and between health outcomes and satisfaction (Alazri and Neal 2003; Marshall, Hays and Mazel 1996; Sequist et al. 2008).

The lack of consistent findings across these studies (Mead and Bower 2002; Doyle, Lennox, and Bell 2013) can be at least partially attributed to the heterogeneity among them in terms of health system organization and Primary Care orientation. Crucially, until now, research on this field has been restricted to pairwise examinations (Marshall, Hays and Mazel 1996; Schneider et al. 2001; Alazri and Neal 2003; Shi et al. 2002; Rao et al. 2006; Kontopantelis, Roland, & Reeves, 2010; Mold et al. 2011; Fenton et al. 2012; Llanwarne et al. 2013; Paddison et al. 2015) or, less frequently, the evaluation of a reduced number of domains of healthcare quality (Safran et al. 1998; Kinnersley 1999; Gandhi et al. 2002; Chang et al. 2006; Sequist et al. 2008), offering only a partial and fragmented picture of the complex network of associations between them. Simultaneously modelling the association between multiple domains of healthcare quality in a single (and large) population would address this gap, offering a more complete and comprehensive approach, testing whether the previous piecemeal approach corresponds to an empirical (not just theoretical) model, minimizing confounding and providing more valid estimations of the existing associations.

This study attempted to provide a unifying model by exploring potential relationships between various domains of care known to be markers of ‘quality’. The aim of this study was to examine the associations between the different domains of quality of primary healthcare in family (general) practices in England.

METHODS

Data sources

We conducted a cross-sectional study using data from English family practices. In England family practices are the places where general practitioners (GPs) work. They usually work as part of a team which includes nurses, healthcare assistants, practice managers, receptionists and other staff. The vast majority of the population is registered with a family practice for the provision of primary care services which are free at the point care. Computerization is almost complete (with electronic medical records operating in the vast majority of the practices) and driven by participation in the profitable the Quality and Outcomes Framework (QOF), a national pay-for-performance scheme (Roland 2004).

Data on indicators for quality of the healthcare provided by family practices in England for the financial year 2011-2012 was obtained from reporting systems for two major quality improvement initiatives in primary care in England: the QOF (Roland 2004), and the GP Patient Survey (GPPS) (Campbell et al. 2009).

QOF is a voluntary scheme that financially rewards practices for their performance across a range of quality indicators. In the financial year 2011-2012 it included a total of 141 indicators. QOF data can be obtained from the Quality Management and Analysis System (QMAS), which automatically extracts data from the clinical record systems of practices. For each QOF indicator practices accumulate points according to their level of achievement, each point being associated with a financial benefit.

The GPPS is a survey capturing the experiences of patients who have been continuously registered with a practice for at least 6 months. This survey includes 46 questions, and is mailed each year to 2.7 million patients. 246 indicators of quality of care as perceived and self-reported by patients are derived from the survey. Each indicator depends on the percentage of patients from a practice giving a specific answer to an item in the survey

(e.g., percentage of patients rating their experience of their GP surgery as “very good”). The overall mortality-adjusted response rate was 40% for the 2011-2012 year. Additional details of the survey are available elsewhere (Campbell et al. 2009).

All the data above described was extracted from the Health & Social Care Information Centre (Health and Social Care Information Centre 2015).

Study sample

The dataset contained a total of 8,433 practices (99% of all practices in England). Of these, 310 practices did not contain QOF data, and 99 had no data relating to GPPS (possibly on account of merging and reconfiguring of practices within the data collection timeframe relevant to this study) and were excluded. Thirteen practices were also excluded because they offered only non-standard services (e.g. walk in services, addiction services) or have skewed patient populations (e.g. only care home or university students). Additionally 404 practices had incomplete data on some GPPS indicators (most frequently on the indicator measuring “frequency of seeing preferred GP”) and were excluded, leaving 7,607 practices in the final dataset (91.2% of all practices in England). Generally, the 404 practices excluded due to incomplete data in some GPPS indicators were very similar (according to the data extracted about their characteristics) to those that remained included.

Development of the conceptual model

A conceptual model was developed to describe hypothesized relationships between the different domains of quality of healthcare and health outcomes. The model, based on the conceptualization of quality of healthcare proposed by Donabedian (Donobedian 1966), was developed in an iterative process started by two members of the research team, and subsequently reviewed and approved by the all members of the team. We operationalized

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3 fundamental domains for quality of care relating to structure (access), processes of care
4 (clinical management, person centeredness), and outcomes (intermediate outcomes, health
5 status, and patient satisfaction); and hypothesized the relationships between them (see Online
6 Appendix 1). Subsequently we examined all the indicators available in the two datasets, and
7 allocated them to the putative domains of quality, adding domains where a homogeneous set
8 of indicators measuring a distinct area of quality was not covered by existing domains.
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10 Indicators that did not offer information for any of the fundamental domains were not
11 included in the study. Although not originally a criterion for the identification of domains, the
12 resulting domains exclusively contained indicators from one of the two data sources, but not
13 both. The allocation of QOF indicators to each of the domains was to a large degree based on
14 the indicators' classification produced by the National Institute for Health and Care
15 Excellence (Prescribing and Primary Care team, Health and Social Care Information Centre
16 2012). The allocation of GPPS indicators was based on previous work that identified a set of
17 composite markers that summarize the different aspects of the survey (Sizmur 2012).
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34 For items in the GPPS we selected those indicators retaining the maximum amount of
35 information based on the distribution of the scores at practice level (i.e., the indicators
36 corresponding to the response category most frequently selected by respondents). These were
37 consistently those capturing the most positive healthcare experience (e.g., 'very good'
38 experience of making an appointment as opposed to other potential responses to that item).
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40 Finally, "health status" indicators were obtained from the responses to the EQ-5D (Brooks
41 1996), a standardized measure of health outcomes that was administered as part of the GPPS.
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50 As part of its development process, the model was redefined because of inadequate
51 fit. This was undertaken based on clinical and statistical criteria, and consisted in removing
52 from the model the latent variables "records and information" (mostly related to information
53 systems), and "overall structure" (accounting for key structural characteristics of the
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practices). The final model included the following nine domains (137 indicators): quality assurance (16), education and training (6), medicine management (8), access to the practice (9), clinical management (70), patient-centered care (12), patient satisfaction (2), intermediate health outcomes (9), and health status (5). The complete list of indicators used to measure each of the domains is available in the Online Appendix 2.

Statistical analysis

We used a hybrid structural equation model (SEM) combining factor and path analysis (Kline and Santor 1999) to empirically test the associations between the quality domains hypothesized in the conceptual model.

Prior to analysis, an assessment of model identification was made using the two-step rule (Bollen 1989). Latent variables were constructed to measure each of the quality domains based on the indicators allocated to each of them. The suitability of the allocation of each indicator to its corresponding domain was examined based on their loadings after confirmatory factor analysis and their internal consistency (Cronbach’s alpha). A correlation matrix for all the latent variables was subsequently constructed. Finally the association between domains was tested with path analysis.

Statistical analysis comprised the estimation of non-standardized and standardized coefficients for the conceptual model (using the maximum likelihood estimator) and assessments of model fit (assessment of Chi-squared (Kline 2015), Standardized Root Mean Squared Residual (SRMR) (Kline and Santor 1999), Comparative Fit Index (Hoyle 1995), Root Mean Squared Error of Approximation (RMSEA), and equation-level goodness of fit).

We needed to redefine the model because of inadequate fitness. This was done based on clinical and statistical criteria and consisted in removing from the model the latent variables “records and information” (mostly related to information systems based on alerts),

and “overall structure” (accounting for all the structural characteristics of the practices that would affect healthcare quality). Once an adequate model was successfully identified, we tested a number of alternative similar models to better understand the associations between the different domains and to examine the consistency of our findings against different data modelling approaches (Hays and White 1987). More specifically, five alternative models were tested in order to explore: 1) reversed causality for some of the hypothesized associations (e.g. patient satisfaction impacting on self-reported health rather than vice versa), and; 2) impact of allocating indicators into broader domains (e.g. collapsing the domains “quality assurance”, “education and training”, and “medicine management” into a single “structure of care” domain). The initial alternative models failed to converge and modifications were introduced in the subsequent models with a view of optimizing parsimony and achieving convergence.

All analyses were carried out in Stata v12.1 and we used an alpha level of 5% throughout.

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RESULTS

General characteristics of the practices are presented in Table 1. According to the NHS Patient Register, the number of patients registered with the practices in this study during the study period was 54,299,945 (mean number of patients per practice: 7,084 (standard deviation (SD) = 4,144).

[TABLE 1 ABOUT HERE]

Cronbach’s α and confirmatory factor analysis loadings indicated adequate internal consistency and structural validity of all the nine final domains (Table 2).

[TABLE 2 ABOUT HERE]

The matrix of correlations between the domains is shown in the Table 3. The highest correlations were observed for the pairs “patient-centered care” and “patient satisfaction” ($r=0.88$), “clinical management” and “intermediate outcomes” ($r=0.69$), and “medicine management” and “education and training” ($r=0.67$). The highest correlation coefficient for “health status” was with “patient satisfaction” ($r=0.05$) and “patient-centered care” (-0.05).

[TABLE 3 ABOUT HERE]

Figure 1 shows the results of the final model used to examine the associations between the quality domains (confidence intervals available in Table 4). The 137 observed variables provided 9590 variances and covariances, and the model estimated contained 432 parameters with 9158 degrees of freedom. We report standardized coefficients, which can be interpreted as standard regression coefficients and that allow for direct comparison (e.g. a one

SD increase in “education and training” is associated with a 0.32 SD increase in “clinical management”, but with a smaller 0.09 SD increase in “patient-centered care”).

[TABLE 4 ABOUT HERE]

According to the magnitude of the standardized coefficients, the model suggested two distinct paths. In the first path, “access to the practice” was associated with “patient-centered care” ($\beta=0.63$), which in turn was strongly associated with “patient satisfaction” ($\beta=0.88$). In the second path, “education and training” was associated with “clinical management” ($\beta=0.32$), which in turn was strongly associated with “intermediate outcomes” ($\beta=0.70$). These two paths were substantially independent, with weak associations between “clinical management” and “patient-centered care” ($\beta=0.08$), and between “clinical management” and “patient satisfaction” ($\beta=0.05$). Finally, “health status” was weakly associated with “patient-centered care” ($\beta=-0.05$), and “patient satisfaction” ($\beta=-0.09$), but not with “clinical management” or “intermediate outcomes”.

[FIGURE 1 ABOUT HERE]

The chi-squared test indicated that the model performed significantly poorer than the saturated model (likelihood ratio test of model vs. saturated: $\chi^2(9158)=296452.6$, $\text{Prob}>\chi^2 = 0.000$). However this test is sensitive with very large sample sizes and alternative measures (SRMR and RMSEA, with values of 0.07 and 0.06 respectively) indicated adequate model fit (Steiger 1990). This was however not supported by the comparative fit index (0.58), with a value below the recommended 0.9. The coefficient of determination for the whole model (with similar interpretation to R-squared) was 0.99.

Equation level goodness of fit statistics showed that the model explained a high proportion of variability in “patient satisfaction” (R-squared =78%), “intermediate outcomes” (48%), and “patient-centered care” (42%). However the model performed less well for “clinical management” (13%) and “health status” (0.3%).

Only one of the five alternative models considered successfully converged. The results from this alternative model (available in Online Appendix 3) generally supported our main findings, observing positive associations between “structure of care” (derived from indicators from the sub-domains “quality assurance”, “education and training” and “medicine management”) and “clinical management”, which in turn was associated with “intermediate outcomes” and with “patient experience” (derived from indicators from “access to practices”, “patient centeredness”, and “patient satisfaction”). Self-reported health was not associated with patient experience or with intermediate outcomes.

DISCUSSION

In this study we used a structural equation model to examine the network of associations between multiple domains of the quality of healthcare provided in family practices in England. We identified two independent paths. The first path links access to practices to patient-centered care and to patient satisfaction. The second path links education and training to clinical management of care and to intermediate outcomes. Patient reported health status was very weakly associated with patient-centered care and patient satisfaction, and not associated with clinical management or intermediate outcomes.

Strengths and limitations

This study has a number of strengths. It includes data for the great majority of QMAS practices in England (covering over 99% of patients). In addition it simultaneously examines the association between multiple domains of healthcare quality by using robust analytic methods and a large number of evidence-based indicators which rely on information provided both by clinicians and patients. But some limitations need to be taken into account. First, the cross-sectional nature of this study makes causal inference problematic. Reversed associations are implausible in most of the cases, but not always (e.g. we hypothesized intermediate outcomes to affect patient satisfaction, but inversed causality is also plausible as more satisfied patients could be more adherent to treatment recommendations, which could result in better intermediate outcomes). Future research using longitudinal designs is needed to better model causal effects. Second, following established recommendations (Hays and White 1987) we considered a number of alternative structural equation models to better understand the associations between the different domains of quality of healthcare tested in our main model. However only one of them could be successfully estimated (which generally supported our main findings), and we cannot rule out the possibility of other alternative

models leading to a different interpretation of our data. Third, our study was restricted to practice-level analysis and did not allow us to draw conclusions about patient-level associations. Practice level analysis, however, is of inherent interest and can inform relevant aspects such as resource allocation and primary care configuration. Four, data for this study was obtained from two different sources, and each quality domain was based on information from only one of them. This could have resulted in an overestimation of the magnitude of the associations between domains from the same source, and an underestimation of the associations from different sources. Fifth, although we used established measures of family practice quality in England, some limitations intrinsic to both sources may have affected our findings. Concerns relating to a low response rate and low reliability have been raised with respect to the GPPS. However, there is little evidence that low response rates have introduced bias (Campbell et al. 2009), and research shows that most survey questions used in this study meet stringent guidelines for reliability (Lyrtzopoulos et al. 2011). QOF indicators measure only a fraction of the healthcare provided by a practice to their patients, and the analysis of other (non-incentivized) activities might yield different results. Finally, the model did not include practice characteristics such as deprivation or size that have been previously associated with performance. A decision was made not to include those additional variables to facilitate model convergence. Similarly, it would have been desirable to include in the model hospital admissions or mortality rates, but this information was not readily available.

Interpretation of results and implications for health services organization

The first path suggests that patients’ ease of access to their practice is associated with patient-centered care, and that patient satisfaction is higher in those practices with higher levels of patient-centered care. The observed relationship between access and patient-centered care may suggests that, by enhancing access, practices may create a platform from which to

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3 develop opportunities for a partnership between patient and clinicians that accounts for the
4 patient's position and feelings. This would support the idea of prioritizing resources for
5 improving access to family practices. The observed relationship between patient-centered
6 care and patient satisfaction has been reported previously (Kinnersley et al. 1999; Lewin et al.
7 2001) and has strong face validity. A recent patient level study including more than 2 million
8 patients responding to the GP Patient Survey observed that doctor communication was the
9 most important patient experience factor driving satisfaction (Paddison et al. 2015).

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12 The second path identified suggests that practices with higher levels of training and
13 education are better equipped to deliver high quality clinical care, having a more positive
14 impact on intermediate health outcomes. This finding has strong face validity, and supports
15 the clinical aspects that are incentivized as part of QOF scheme in the UK. In addition, it
16 highlights the importance of adequate training, identifying it as a priority area for resource
17 allocation. Interestingly however, although the education and training provided to healthcare
18 professionals was associated with better clinical management, its association with patient-
19 centered care was very weak. This suggests that current training initiatives might have a very
20 strong clinical orientation, in line with observations from previous research (Tsimtsiou et al.
21 2007). An increased focus on patient-centered education (which could be achieved for
22 example by involving patients in training programs, which have shown to produce sustained
23 gains in levels of interpersonal skills (Greco, Brownlea, and McGovern 2001)), may
24 represent an opportunity of quality improvement worth exploring.

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27 We observed a weak positive association between clinical management and patient-
28 centered care and satisfaction, which was stronger in our alternative model. Previous studies
29 analyzed the relationship between clinical management and patient experiences in primary
30 care settings, reporting findings ranging from no association (Gandhi et al. 2002; Chang et al.
31 2006; Rao et al. 2006) to modest positive associations (Schneider et al. 2001; Sequist et al.

2008; Llanwarne et al. 2013). Studies in secondary care reported moderate (Lehrman et al. 2010) or strong (Jha et al. 2008; Isaac et al. 2010; Stein et al. 2014) positive associations. The positive association observed in our study does not support the idea that encouraging doctors to concentrate on technical aspects of care, incentive schemes such as the QOF will lead to deterioration in the doctor-patient relationship, or vice versa.

Unexpectedly, medicine management was negatively associated with clinical management. Although it may be hypothesized that adequate medicine management may be resource consuming and it may occur at the expense of high quality processes of care, there is little evidence to support such a view. We are therefore unable to explain the observed association, and more research is needed to confirm this inverse relationship and eventually elucidate the mechanisms by which it might operate.

Although patient-reported outcome measures have been traditionally regarded as a measure of need rather than performance, in recent years there has been a growing interest in their use for performance assessment of the health system and for benchmarking and quality improvement purposes in healthcare organizations (Nelson et al. 2015). In our study, self-reported health status was very weakly associated with patient-centered care, and we observed no association with clinical management or intermediate outcomes. Similar findings were observed in our alternative model. Our findings are consistent with a previous study which observed no association between patients' baseline assessments of the quality of primary care they received and subsequent changes in health-related quality of life and survival (Mold et al. 2011). However this contrasts with previous primary care specific studies supporting a link between primary care supply and positive perceived health (Shi et al. 1999; Shi and Starfield 2000; Shi and Starfield 2001). More specifically it has been observed that good primary care experience, in particular enhanced accessibility and continuity, is associated with better self-reported health both generally and mentally (Shi et

al. 2002). A number of aspects need to be taken into account when interpreting the lack of association observed in our study. First, the fact that we used self-reported health status aggregated at the practice level may have reduced our ability to detect a potential association. An individual patient receiving good quality of primary healthcare is more likely to have better health outcomes than a patient receiving poor primary healthcare. However the same does not necessarily apply at the practice level, as measures of population health are more likely to be influenced by environmental and social factors. Second, the potential impact of processes of care on health outcomes is likely to occur in a longer period of time than, for example, the impact of processes of care on patient satisfaction or intermediate outcomes. The cross-sectional nature of our study thus hindered our ability to examine this specific relationship. Finally, it is well known that health status is correlated with multiple factors beyond the GP's control. This include genetic variation (it has been estimated that one-third of the variability of self-reported health can be attributed to genes (Romeis et al. 2000)), but also by other personal, social, economic, and environmental factors (Dahlgren and Whitehead 1991), which were not included in our study. Therefore a hypothetical small effect such as the one described by Shi et al. (2002) cannot be ruled out by the findings of this study because of the methodological constraints described above. Although we think our model is of relevance in reflecting the status of the healthcare system, we acknowledge that it may be of more limited value in reflecting health.

Self-reported health status was weakly associated with patient satisfaction, which supports previous research from the hospital setting (Hays et al. 2006). An inverse association may be plausible in this case (more satisfied patients could have higher adherence to treatment recommendations and therefore have better health outcomes), and has been observed in a previous longitudinal study (Marshall, Hays and Mazel 1996). However we tested this inverse association in our alternative model, observing that patient experience was

not associated with self-reported health. Our results might reflect that patients with poorer health constitute a particular group of primary care service users not only in respect of above-average service use, but also in respect of the range and type of services used, particularly reflective of lower levels of overall satisfaction with healthcare services. This is in line with a recent study observing that patients with multimorbidity more frequently report worse experiences in primary care (Paddison et al. 2015). This could have implications for quality improvement initiatives, as segmenting the patient population by their medical needs could enable patients' feedback to indicate where quality improvements are required for specific groups. Other industries have been successful in understanding where to make improvements for consumers through data segmentation techniques that identify specific groups within the population (Flott et al. 2016).

Conclusion

By including an unprecedented number of factors within a single statistical model, this study was able to describe the network of associations between multiple domains of quality of healthcare provided in Primary Care in England. This is the first empirical model simultaneously providing evidence on the independence of all intermediate health care outcomes, patient satisfaction, and health status. The explanatory paths via technical quality clinical management and patient centeredness offer specific opportunities for the development of quality improvement initiatives. Further longitudinal and patient level studies are needed to confirm our findings.

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For Peer Review

Table 1. Characteristics of General Practices included in the study (N=7,607)

	Mean (SD)	Range
Number of registered patients	7,084 (4144)	597; 44,071
Female	50.37 (5.59)	20.28; 75.47
Age (%)		
18-24 years	9.83 (5.66)	0; 86.17
25-34 years	17.49 (8.19)	0; 70.07
35-44 years	18.43 (5.20)	0; 44.87
45-54 years	18.32 (4.11)	0; 37.42
55-64 years	15.02 (4.43)	0; 32.92
65-74 years	11.20 (4.25)	0; 28.44
75-84 years	6.95 (2.99)	0; 21.56
≥85 years	2.75 (1.61)	0; 11.62
Race (%)		
White	84.24 (21.90)	0; 100
Black	3.26 (6.54)	0; 64.13
Asian	8.25 (14.61)	0; 93.56
Index of multiple deprivation*	23.52 (12.08)	2.86; 66.38

*McLennan et al. 2011. The English Indices of Deprivation 2010: Technical Report. 2011.

Table 2. Characteristics of the healthcare quality domains considered

	Source	Number of indicators	Cronbach's α [†]	Confirmatory factor analysis (loadings range)
Education and training	QOF	6	0.72 (0.67; 0.72)	0.47; 0.65
Medicines management	QOF	8	0.84 (0.80; 0.85)	0.35; 0.87
Quality assurance	QOF	16	0.86 (0.85; 0.86)	0.30; 0.76
Access to the practice	GPPS	8	0.92 (0.90; 0.92)	0.49; 0.99
Clinical management	QOF	70	0.94 (0.93; 0.94)	0.07; 0.63
Patient-centered care	GPPS	12	0.97 (0.96; 0.97)	0.64; 0.97
Patient satisfaction	GPPS	2	0.96 (NA)	0.95; 0.96
Intermediate outcomes	QOF	9	0.81 (0.77; 0.81)	0.39; 0.74
Health status	GPPS	5	0.92 (0.88; 0.93)	0.39; 0.74

[†] Mean (minimum; maximum); QOF, quality and outcomes framework; GPPS, GP Patient Survey; NA: Not applicable

Table 3. Correlations between the healthcare quality domains

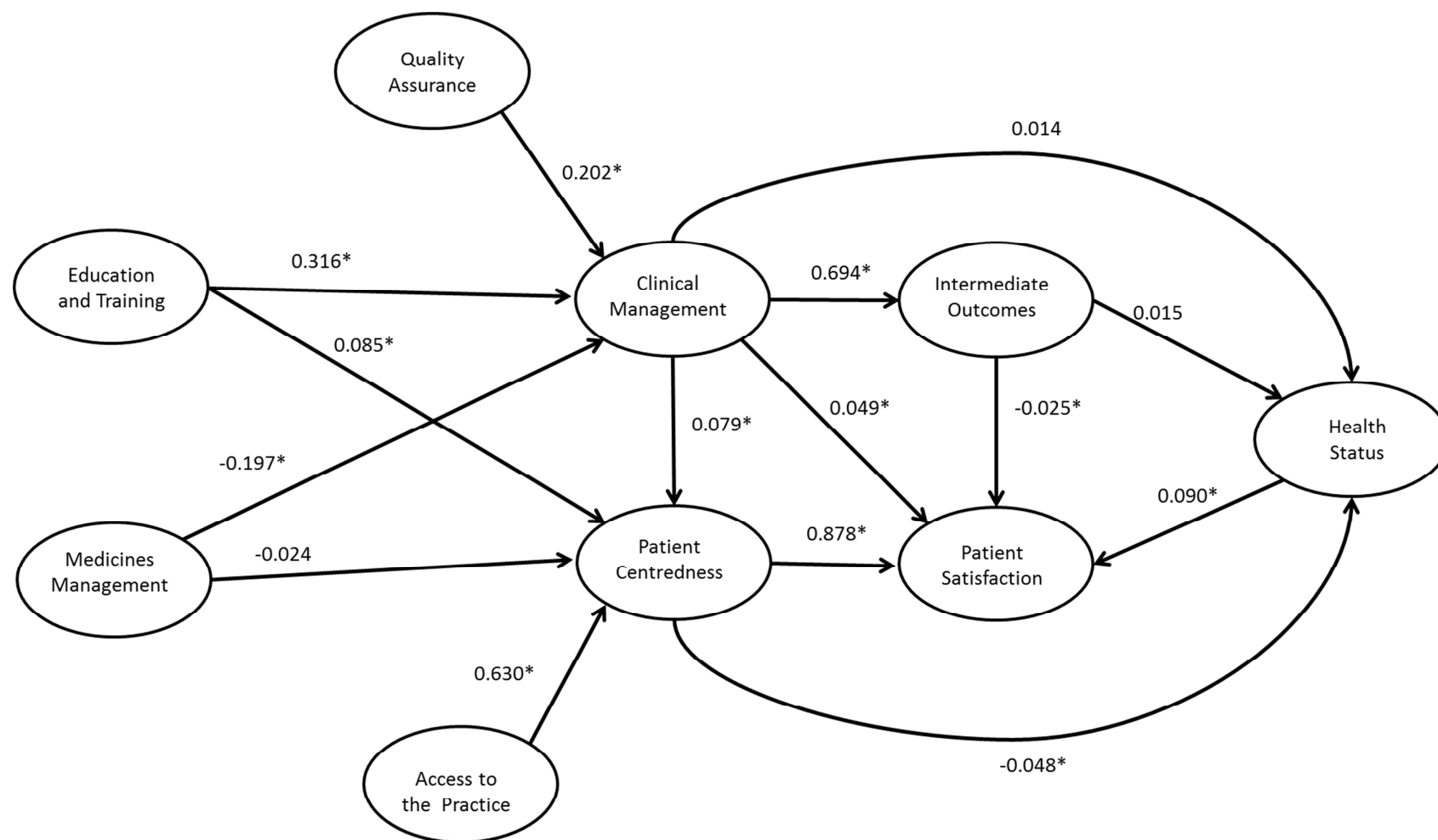
	Quality assurance	Education and Training	Medicines Management	Access to the practice	Clinical management	Patient-centred care	Intermediate Outcomes	Patient Satisfaction	Health Status
Quality assurance	1	0.634	0.605	0.026	0.284	0.078	0.197	0.078	0.003
Education and Training	0.634	1	0.670	0.026	0.313	0.110	0.217	0.107	0.021
Medicines Management	0.605	0.670	1	0.018	0.138	0.056	0.095	0.053	0.001
Access to the practice	0.026	0.026	0.018	1	0.010	0.632	0.067	0.553	-0.030
Clinical management	0.284	0.313	0.138	0.010	1	0.109	0.694	0.129	0.019
Patient-centred care	0.078	0.110	0.056	0.632	0.109	1	0.076	0.878	-0.045
Intermediate Outcomes	0.197	0.217	0.095	0.067	0.694	0.076	1	0.077	0.020
Patient Satisfaction	0.078	0.107	0.053	0.553	0.129	0.878	0.077	1	0.051
Health Status	0.003	0.021	0.001	-0.030	0.019	-0.045	0.020	0.051	1

Table 4. Associations between healthcare quality in the final structural equation model.

Structural Effect/ Path coefficient	β	95 % CI	
Patient-centered care to Patient satisfaction	0.878	0.872	0.885
Clinical management to Intermediate outcomes	0.694	0.678	0.709
Access to practice to Patient-centered care	0.630	0.616	0.644
Education and training to Clinical management	0.316	0.272	0.360
Quality assurance to Clinical management	0.202	0.166	0.238
Medicines management to Clinical management	-0.197	-0.236	-0.158
Health status to Patient satisfaction	0.090	0.077	0.103
Education and training to Patient-centered care	0.085	0.052	0.118
Clinical management to Patient-centered care	0.079	0.060	0.099
Clinical management to Patient satisfaction	0.049	0.030	0.068
Patient-centered care to Health status	-0.048	-0.071	-0.024
Intermediate outcomes to Patient satisfaction	-0.025	-0.045	-0.006
Medicines management to Patient-centered care	-0.024	-0.053	0.006
Intermediate outcomes to Health status	0.015	-0.024	0.053
Clinical management to Health status	0.014	-0.023	0.050

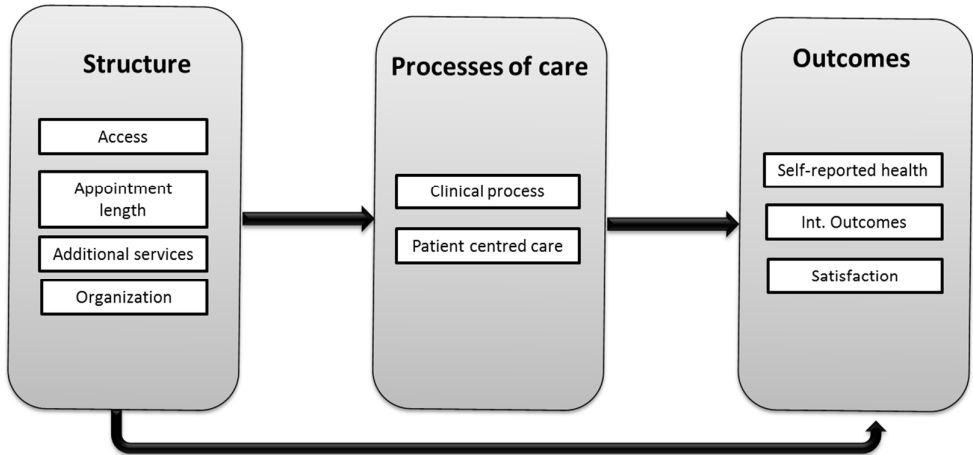
β , standardized coefficients; CI, confidence interval

Figure 1. Associations between healthcare quality and health outcome domains. Results from the final structural equation model.



Statistically significant associations ($p < 0.05$) are noted with an asterisk (*).

Online Appendix 1. Initial model proposed to describe the associations between the different domains of quality in primary care.



Online Appendix 2. Observed and latent variables included in the final structural equation model[¶]

	Mean (SD)	Range	Loading* (CI95%)
Education and Training			
There is a record of all practice-employed staff having attended training/updating in basic life support skills in the preceding 36 months	5.86 (0.91)	0.00; 6.00	0.472 (0.451; 0.492)
The practice conducts an annual review of patient complaints and suggestions to ascertain general learning points which are shared with the team	5.94 (0.60)	0.00; 6.00	0.559 (0.541; 0.578)
The practice has undertaken a minimum of 12 significant event reviews in the preceding 3 years which could include: Any death occurring in the practice premises/ New cancer diagnoses /Deaths where terminal care has taken place at home/ Any suicides/ Admissions under the Mental Health Act/ Child protection cases/ Medication errors/ A significant event occurring when a patient may have been subjected to harm, had the circumstance/outcome been different (near miss)	32.70 (3.13)	0.00; 33.00	0.577 (0.558; 0.596)
All practice-employed nurses have personal learning plans which have been reviewed at annual appraisal	2.98 (0.25)	0.00; 3.00	0.547 (0.522; 0.562)
All practice-employed non-clinical team members have an annual appraisal	2.92 (0.48)	0.00; 3.00	0.493 (0.472; 0.515)
The practice has undertaken a minimum of 3 significant event reviews within the preceding year	2.92 (0.48)	0.00; 3.00	0.654 (0.636; 0.671)
Medicines Management			
The practice possesses the equipment and in-date emergency drugs to treat anaphylaxis	1.98 (0.22)	0.00; 2.00	0.585 (0.569; 0.601)
There is a system for checking expiry dates of emergency drugs on at least an annual basis	1.99 (0.16)	0.00; 2.00	0.779 (0.768; 0.789)
The number of hours from requesting a prescription to availability for collection by the patient is 72 hours or less (excluding weekends and bank/local holidays)	2.99 (0.21)	0.00; 3.00	0.871 (0.864; 0.879)
The practice meets with the PCO prescribing adviser at least annually and agrees up to three actions related to prescribing	3.98 (0.27)	0.00; 4.00	0.768 (0.757; 0.778)
The number of hours from requesting a prescription to availability for collection by the patient is 48 hours or less (excluding weekends and bank/local holidays)	5.95 (0.53)	0.00; 6.00	0.743 (0.731; 0.754)
The practice meets with the PCO prescribing adviser at least annually, has agreed up to three actions related to prescribing and subsequently provided evidence of change	3.86 (0.73)	0.00; 4.00	0.347 (0.326; 0.368)
The practice conducts an internal review of their prescribing to assess whether it is clinically appropriate and cost effective, agrees with the PCO three areas for improvement and produces a draft plan for each area no later than 30 June 2011	5.95 (0.56)	0.00; 6.00	0.494 (0.476; 0.513)
The practice participates in an external peer review of prescribing with a group of practices and agrees plans for three prescribing areas for improvement firstly with the group and then with the PCO no later than 30 September 2011	6.91 (0.77)	0.00; 7.00	0.473 (0.453; 0.492)
Quality assurance			
The practice meets internally to review the data on secondary care outpatient referrals provided by the PCO	4.87 (0.79)	0.00; 5.00	0.753 (0.730; 0.776)
The practice participates in an external peer review with a group of practices to compare its secondary care outpatient referral data either with practices in the group of practices or with practices in the PCO area and proposes areas for commissioning or service design improvements to the PCO	4.87 (0.80)	0.00; 5.00	0.744 (0.722; 0.766)
The practice engages with the development of and follows 3 agreed care pathways for improving the management of patients in the primary care setting (unless in individual cases they justify clinical reasons for not doing this) to avoid inappropriate outpatient referrals and produces a report of the action taken to the PCO no later than 31 March 2012	10.51 (2.27)	0.00; 11.00	0.650 (0.630; 0.669)
The practice meets internally to review the data on emergency admissions provided by the PCO	4.86 (0.82)	0.00; 5.00	0.760 (0.736; 0.783)
The practice participates in an external peer review with a group of practices to compare its data on emergency admissions	14.58 (2.48)	0.00; 15.00	0.757 (0.734; 0.780)

	Mean (SD)	Range	Loading* (CI95%)
either with practices in the group of practices or practices in the PCO area and proposes areas for commissioning or service design improvements to the PCO			
The practice engages with the development of and follows 3 agreed care pathways (unless in individual cases they justify clinical reasons for not doing this) in the management and treatment of patients in aiming to avoid emergency admissions and produces a report of the action taken to the PCO no later than 31 March 2012	26.25 (5.73)	0.00; 27.50	0.647 (0.626; 0.667)
The practice has a policy for auditing its cervical screening service, and performs an audit of inadequate cervical smears in relation to individual smear-takers at least every 2 years	1.95 (0.31)	0.00; 2.00	0.385 (0.356; 0.415)
The practice has a protocol that is in line with national guidance and practice for the management of cervical screening, which includes staff training, management of patient call/recall, exception reporting and the regular monitoring of inadequate smear rates	6.91 (0.78)	0.00; 7.00	0.421 (0.387; 0.455)
Individual healthcare professionals have access to information on local procedures relating to Child Protection	0.99 (0.08)	0.00; 1.00	0.455 (0.416; 0.494)
The hepatitis B status of all doctors and relevant practice employed staff is recorded and immunisation recommended if required in accordance with national guidance	0.49 (0.08)	0.00; 0.50	0.309 (0.282; 0.337)
The practice has systems in place to ensure regular and appropriate inspection, calibration, maintenance and replacement of equipment including a defined responsible person clear recording systematic pre-planned schedules reporting of faults	2.94 (0.42)	0.00; 3.00	0.340 (0.311; 0.370)
The practice has a protocol for the identification of carers and a mechanism for the referral of carers for social services assessment	2.95 (0.37)	0.00; 3.00	0.350 (0.319; 0.380)
There is a written procedure manual that includes staff employment policies including equal opportunities, bullying and harassment and sickness absence (including illegal drugs, alcohol and stress) to which staff have access	1.99 (0.16)	0.00; 2.00	0.468 (0.431; 0.504)
Child development checks are offered at intervals that are consistent with national guidelines and policy	5.86 (0.91)	0.00; 6.00	0.295 (0.266; 0.323)
Antenatal care and screening are offered according to current local guidelines	5.94 (0.60)	0.00; 6.00	0.419 (0.384; 0.454)
The length of routine booked appointments with the doctors in the practice is not less than 10 minutes. [If the practice routinely sees extras during booked surgeries, then the average booked consultation length should allow for the average number of extras seen in a surgery session. If the extras are seen at the end, then it is not necessary to make this adjustment.]. For practices with only an open surgery system, the average face to face time spent by the GP with the patient is at least 8 minutes. Practices that routinely operate a mixed economy of booked and open surgeries should report on both criteria.	32.70 (3.13)	0.00; 33.00	0.416 (0.382; 0.450)
Access to the practice			
Ease of getting through to someone at GP surgery on the phone: % Very easy (excluding responses of "Haven't tried")	0.36 (0.17)	0.01; 0.90	0.492 (0.871; 0.882)
Helpfulness of receptionists at GP surgery: % Very helpful	0.51 (0.14)	0.06; 0.96	0.87 (0.865; 0.877)
Frequency of seeing preferred GP: % Always or almost always	0.43 (0.16)	0.00; 1.00	0.64 (0.624; 0.651)
Able to get an appointment to see or speak to someone: % Yes	0.78 (0.11)	0.33; 1.00	0.784 (0.775; 0.793)
Convenience of appointment: % Very convenient	0.49 (0.11)	0.11; 0.92	0.890 (0.885; 0.895)
Overall experience of making an appointment: % Very good	0.40 (0.15)	0.06; 0.93	0.987 (0.985; 0.989)
Waiting time at surgery: % Less than 15 minutes	0.73 (0.15)	0.05; 1.00	0.450 (0.432; 0.468)
Impression of waiting time at surgery: % Don't normally have to wait too long	0.66 (0.15)	0.12; 1.00	0.603 (0.588; 0.618)
Is your GP surgery currently open at times that are convenient for you?: % Yes	0.80 (0.07)	0.37; 1.02	0.509 (0.493; 0.493)
Clinical management			
The percentage of patients with coronary heart disease with a record in the preceding 15 months that aspirin, an alternative anti-platelet therapy, or an anti-coagulant is being taken (unless a contraindication or side effects are recorded)	6.97 (0.21)	0.00; 7.00	0.465 (0.447; 0.483)

	Mean (SD)	Range	Loading* (CI95%)
The percentage of patients with coronary heart disease who are currently treated with a beta-blocker (unless a contraindication or side effects are recorded)	6.98 (0.27)	0.00; 7.00	0.365 (0.345; 0.385)
The percentage of patients with coronary heart disease who have had influenza immunisation in the preceding 1 September to 31 March	6.89 (0.40)	0.00; 7.00	0.518 (0.501; 0.535)
For patients with newly diagnosed angina (diagnosed after 1 April 2011), the percentage who are referred for specialist assessment	6.66 (1.46)	0.00; 7.00	0.363 (0.349; 0.389)
The percentage of patients with coronary heart disease with a record in the preceding 15 months that aspirin, an alternative anti-platelet therapy, or an anti-coagulant is being taken (unless a contraindication or side effects are recorded)	9.37 (2.28)	0.00;10.00	0.303 (0.282; 0.324)
In those patients with a new diagnosis of hypertension (excluding those with pre-existing CHD, diabetes, stroke and/or TIA) recorded between the preceding 1 April to 31 March; the percentage of patients aged 30 to 74 years who have had a face to face cardiovascular risk assessment at the outset of diagnosis (within 3 months of the initial diagnosis) using an agreed risk assessment tool	7.46 (1.75)	0.00; 8.00	0.501 (0.483; 0.518)
The percentage of patients diagnosed with hypertension (diagnosed after 1 April 2009) who are given lifestyle advice in the preceding 15 months for: increasing physical activity, smoking cessation, safe alcohol consumption and healthy diet	4.85 (0.69)	0.00; 5.00	0.484 (0.466; 0.502)
The percentage of patients with a diagnosis of heart failure (diagnosed after the 1 April 2006) which has been confirmed by an echocardiogram or by specialist assessment	5.94 (0.43)	0.00; 6.00	0.461 (0.442; 0.479)
The percentage of patients with a current diagnosis of heart failure due to Left Ventricular Dysfunction (LVD) who are currently treated with an ACE inhibitor or Angiotensin Receptor Blocker (ARB), who can tolerate therapy and for whom there is no contraindication.	9.91 (0.75)	0.00; 10.00	0.329 (0.308; 0.350)
The percentage of patients with a current diagnosis of heart failure due to LVD who are currently treated with an ACE inhibitor or Angiotensin Receptor Blocker (ARB), who are additionally treated with a beta-blocker licensed for heart failure, or recorded as intolerant to or having a contraindication to beta-blockers	8.90 (0.92)	0.00; 9.00	0.318 (0.297; 0.339)
The percentage of patients with TIA or stroke who have a record of total cholesterol in the preceding 15 months	1.93 (0.18)	0.00; 2.00	0.560 (0.543; 0.576)
The percentage of patients with hypertension in whom there is a record of the blood pressure in the preceding 9 months	15.67 (0.85)	0.00; 16.00	0.538 (0.521; 0.554)
The percentage of patients with diabetes whose notes record BMI in the preceding 15 months	2.98 (0.12)	0.00; 3.00	0.542 (0.525; 0.558)
The percentage of patients with diabetes with a record of neuropathy testing in the preceding 15 months	2.91 (0.28)	0.00; 3.00	0.558 (0.542; 0.574)
The percentage of patients with diabetes who have a record of micro-albuminuria testing in the preceding 15 months (exception reporting for patients with proteinuria)	2.81 (0.39)	0.00; 3.00	0.572 (0.556; 0.588)
The percentage of patients with diabetes with a diagnosis of proteinuria or micro-albuminuria who are treated with ACE inhibitors (or A2 antagonists)	2.94 (0.30)	0.00; 3.00	0.326 (0.305; 0.346)
The percentage of patients with diabetes who have had influenza immunisation in the preceding 1 September to 31 March	2.97 (0.16)	0.00; 3.00	0.493 (0.475; 0.511)
The percentage of patients with diabetes who have a record of retinal screening in the preceding 15 months	4.85 (0.43)	0.00; 5.00	0.456 (0.437; 0.474)
The percentage of patients with diabetes who have a record of estimated glomerular filtration rate (eGFR) or serum creatinine testing in the preceding 15 months	2.99 (0.07)	0.00; 3.00	0.523 (0.505; 0.540)
The percentage of patients with diabetes with a record of a foot examination and risk classification: 1) low risk (normal sensation, palpable pulses), 2) increased risk (neuropathy or absent pulses), 3) high risk (neuropathy or absent pulses plus deformity or skin changes in previous ulcer) or 4) ulcerated foot within the preceding 15 months	3.75 (0.64)	0.00; 4.00	0.561 (0.545; 0.577)
The percentage of patients with COPD who have had influenza immunisation in the preceding 1 September to 31 March	5.97 (0.28)	0.00; 6.00	0.460 (0.441; 0.478)
The percentage of patients with COPD with a record of FEV1 in the preceding 15 months	6.92 (0.60)	0.00; 7.00	0.484 (0.466; 0.502)
The percentage of patients with COPD who have had a review, undertaken by a healthcare professional, including an	8.67 (1.20)	0.00; 9.00	0.630 (0.616; 0.644)

	Mean (SD)	Range	Loading* (CI95%)
assessment of breathlessness using the MRC dyspnoea score in the preceding 15 months			
The percentage of all patients with COPD diagnosed after 1 April 2011 in whom the diagnosis has been confirmed by post bronchodilator spirometry	4.74 (1.06)	0.00; 5.00	0.448 (0.430; 0.467)
The percentage of patients aged 18 years and over on drug treatment for epilepsy who have a record of seizure frequency in the preceding 15 months	3.95 (0.27)	0.00; 4.00	0.525 (0.508; 0.542)
The percentage of women under the age of 55 years who are taking antiepileptic drugs who have a record of information and counselling about contraception, conception and pregnancy in the preceding 15 months	2.64 (0.90)	0.00; 3.00	0.421 (0.402; 0.441)
The percentage of patients with hypothyroidism with thyroid function tests recorded in the preceding 15 months	5.99 (0.14)	0.00; 6.00	0.421 (0.402; 0.441)
The percentage of patients with cancer, diagnosed within the preceding 18 months, who have a patient review recorded as occurring within 6 months of the practice receiving confirmation of the diagnosis	5.70 (1.02)	0.00; 6.00	0.475 (0.457; 0.493)
The practice has regular (at least 3 monthly) multidisciplinary case review meetings where all patients on the palliative care register are discussed	2.71 (0.88)	0.00; 3.00	0.314 (0.293; 0.335)
The percentage of patients on the register who have a comprehensive care plan documented in the records agreed between individuals, their family and/or carers as appropriate	5.99 (0.20)	0.00; 6.00	0.202 (0.180; 0.225)
The percentage of patients with schizophrenia, bipolar affective disorder and other psychoses who have a record of alcohol consumption in the preceding 15 months.	3.73 (0.67)	0.00; 4.00	0.616 (0.601; 0.631)
The percentage of patients with schizophrenia, bipolar affective disorder and other psychoses who have a record of BMI in the preceding 15 months	3.71 (0.62)	0.00; 4.00	0.622 (0.607; 0.636)
The percentage of patients with schizophrenia, bipolar affective disorder and other psychoses who have a record of blood pressure in the preceding 15 months	3.85 (0.40)	0.00; 4.00	0.609 (0.594; 0.624)
The percentage of patients aged 40 years and over with schizophrenia, bipolar affective disorder and other psychoses who have a record of total cholesterol-hdl ratio in the preceding 15 months	4.55 (1.05)	0.00; 5.00	0.557 (0.541; 0.573)
The percentage of patients aged 40 years and over with schizophrenia, bipolar affective disorder and other psychoses who have a record of blood glucose in the preceding 15 months	4.70 (0.82)	0.00; 5.00	0.598 (0.583; 0.613)
The percentage of women (aged from 25 to 64 in England and Northern Ireland, from 20 to 60 in Scotland and from 20 to 64 in Wales) with schizophrenia, bipolar affective disorder and other psychoses whose notes record that a cervical screening test has been performed in the preceding 5 years	4.82 (0.69)	0.00; 5.00	0.301 (0.280; 0.322)
The percentage of patients on lithium therapy with a record of serum creatinine and TSH in the preceding 9 months	0.92 (0.25)	0.00; 1.00	0.275 (0.254; 0.297)
The percentage of patients with asthma between the ages of 14 and 19 years in whom there is a record of smoking status in the preceding 15 months	5.93 (0.42)	0.00; 6.00	0.382 (0.362; 0.401)
The percentage of patients with asthma who have had an asthma review in the preceding 15 months	19.78 (1.28)	0.00; 20.00	0.476 (0.458; 0.494)
The percentage of patients aged 8 years and over diagnosed as having asthma from 1 April 2006 with measures of variability or reversibility	14.77 (1.32)	0.00; 15.00	0.472 (0.454; 0.490)
The percentage of patients diagnosed with dementia whose care has been reviewed in the preceding 15 months	14.82 (1.49)	0.00; 15.00	0.443 (0.425; 0.462)
The percentage of patient with a new diagnosis of dementia (from 1 April 2011) with a record of FBC, calcium, glucose, renal and liver function, thyroid function tests, serum vitamin B12 and folate levels recorded 6 months before or after entering on to the register	4.84 (2.18)	0.00; 6.00	0.414 (0.394; 0.433)
The percentage of patients on the diabetes register and/or the CHD register for whom case finding for depression has been undertaken on one occasion during the preceding 15 months using two standard screening questions	5.63 (0.80)	0.00; 6.00	0.559 (0.543; 0.575)
In those patients with a new diagnosis of depression, recorded between the preceding 1 April to 31 March, the percentage	15.88 (3.34)	0.00; 17.00	0.507 (0.489; 0.524)

	Mean (SD)	Range	Loading* (CI95%)
of patients who have had an assessment of severity at the time of diagnosis using an assessment tool validated for use in primary care			
In those patients with a new diagnosis of depression and assessment of severity recorded between the preceding 1 April to 31 March, the percentage of patients who have had a further assessment of severity 4-12 weeks (inclusive) after the initial recording of the assessment of severity. Both assessments should be completed using an assessment tool validated for use in primary care	6.02 (2.98)	0.00; 8.00	0.482 (0.464; 0.500)
The percentage of patients on the CKD register whose notes have a record of blood pressure in the preceding 15 months	5.99 (0.15)	0.00; 6.00	0.382 (0.362; 0.402)
The percentage of patients on the CKD register with hypertension and proteinuria who are treated with an angiotensin converting enzyme inhibitor (ACE-I) or angiotensin receptor blocker (ARB) (unless a contraindication or side effects are recorded)	8.82 (1.09)	0.00; 9.00	0.311 (0.290; 0.331)
The percentage of patients on the CKD register whose notes have a record of a urine albumin: creatinine ratio (or protein: creatinine ratio) test in the preceding 15 months	5.56 (1.10)	0.00; 6.00	0.516 (0.499; 0.533)
The percentage of patients with atrial fibrillation who are currently treated with anti-coagulation drug therapy or an anti-platelet therapy	11.93 (0.51)	0.00; 12.00	0.445 (0.426; 0.464)
The percentage of patients with atrial fibrillation diagnosed after 1 April 2008 with ECG or specialist confirmed diagnosis	9.90 (0.76)	0.00; 10.00	0.456 (0.437; 0.474)
The percentage of patients on the learning disability register with Down's Syndrome aged 18 years and over who have a record of blood TSH in the preceding 15 months (excluding those who are on the thyroid disease register)	1.94 (1.42)	0.00; 3.00	0.225 (0.203; 0.247)
The percentage of patients with any or any combination of the following conditions: CHD, stroke or TIA, hypertension, diabetes, COPD, asthma, CKD, schizophrenia, bipolar affective disorder or other psychoses whose notes record smoking status in the preceding 15 months	29.97 (0.48)	0.00; 30.00	0.332 (0.311; 0.353)
The percentage of patients with any or any combination of the following conditions: CHD, stroke or TIA, hypertension, diabetes, COPD, asthma, CKD, schizophrenia, bipolar affective disorder or other psychoses who smoke whose notes contain a record that smoking cessation advice or referral to a specialist service, where available, has been offered within the preceding 15 months	29.61 (1.60)	0.00; 30.00	0.493 (0.476; 0.511)
The blood pressure of patients aged 45 years and over is recorded in the preceding 5 years for at least 65% of patients	10.00 (0.20)	0.00; 10.00	0.073 (0.050; 0.096)
The blood pressure of patients aged 45 years and over is recorded in the preceding 5 years for at least 80% of patients	4.95 (0.49)	0.00; 5.00	0.116 (0.093; 0.139)
80% of newly registered patients have had their notes summarised within 8 weeks of receipt by the practice	6.70 (1.42)	0.00; 7.00	0.192 (0.170; 0.215)
The percentage of patients aged 15 years and over whose notes record smoking status in the preceding 27 months	10.00 (1.11)	0.00; 11.00	0.298 (0.277; 0.319)
The practice supports smokers in stopping smoking by a strategy, which includes providing literature and offering appropriate therapy	1.98 (0.19)	0.00; 2.00	0.095 (0.072; 0.117)
The percentage of patients (aged from 25 to 64 in England and Northern Ireland, from 20 to 60 in Scotland and from 20 to 64 in Wales) whose notes record that a cervical screening test has been performed in the preceding 5 years	10.66 (0.96)	0.00; 11.00	0.371 (0.351; 0.391)
The percentage of women prescribed an oral or patch contraceptive method who have also received information from the practice about long acting reversible methods of contraception in the preceding 15 months	2.79 (0.52)	0.00; 3.00	0.428 (0.408; 0.447)
The percentage of women prescribed emergency hormonal contraception at least once in the year by the practice who have received information from the practice about long acting reversible methods of contraception at the time of, or within 1 month of, the prescription	2.73 (0.71)	0.00; 3.00	0.388 (0.368; 0.408)
A medication review is recorded in the notes in the preceding 15 months for all patients being prescribed 4 or more repeat medicines Standard 80%	6.90 (0.81)	0.00; 7.00	0.201 (0.179; 0.224)
A medication review is recorded in the notes in the preceding 15 months for all patients being prescribed repeat medicines Standard 80%	7.76 (1.36)	0.00; 8.00	0.235 (0.213; 0.257)

	Mean (SD)	Range	Loading* (CI95%)
The percentage of prescriptions complying with the agreed plan for the first improvement area as a percentage of all prescriptions in that improvement area during the period 1 January 2012 to 31 March 2012	4.27 (1.31)	0.00; 5.00	0.125 (0.102; 0.147)
The percentage of prescriptions complying with the agreed plan for the second improvement area as a percentage of all prescriptions in that improvement area during the period 1 January 2012 to 31 March 2012	4.25 (1.38)	0.00; 5.00	0.150 (0.127; 0.172)
The percentage of prescriptions complying with the agreed plan for the third improvement area as a percentage of all prescriptions in that improvement area during the period 1 January 2012 to 31 March 2012	4.28 (1.44)	0.00; 5.00	0.128 (0.105; 0.150)
The percentage of patients with TIA or stroke who have had influenza immunisation in the preceding 1 September to 31 March	1.96 (0.15)	0.00; 2.00	0.522 (0.505; 0.539)
The percentage of patients with a stroke shown to be non-haemorrhagic, or a history of TIA, who have a record that an anti-platelet agent (aspirin, clopidogrel, dipyridamole or a combination), or an anti-coagulant is being taken (unless a contraindication or side effects are recorded)	3.97 (0.22)	0.00; 4.00	0.434 (0.415; 0.453)
The percentage of new patients with a stroke or TIA who have been referred for further investigation	1.95 (0.26)	0.00; 2.00	0.439 (0.420; 0.458)
The percentage of patients on lithium therapy with a record of lithium levels in the therapeutic range in the preceding 4 months	1.65 (0.65)	0.00; 2.00	0.368 (0.348; 0.388)
Patient centredness			
Rating of GP giving you enough time: % Very good	0.50 (0.12)	0.11; 0.93	0.959 (0.957; 0.961)
Rating of GP listening to you: % Very good	0.53 (0.12)	0.13; 0.92	0.965 (0.963; 0.966)
Rating of GP explaining tests and treatments: % Very good	0.50 (0.12)	0.10; 0.92	0.960 (0.959; 0.962)
Rating of GP involving you in decisions about your care: % Very good	0.44 (0.12)	0.09; 0.89	0.964 (0.962; 0.966)
Rating of GP treating you with care and concern% Very good	0.49 (0.12)	0.07; 0.91	0.972 (0.971; 0.974)
Confidence and trust in GP: % Yes, definitely	0.67 (0.11)	0.27; 0.98	0.904 (0.900; 0.908)
Rating of nurse giving you enough time: % Very good	0.56 (0.12)	0.12; 0.92	0.687 (0.675; 0.699)
Rating of nurse listening to you: % Very good	0.54 (0.11)	0.13; 0.91	0.676 (0.663; 0.688)
Rating of nurse explaining tests and treatments: % Very good	0.53 (0.11)	0.12; 0.91	0.686 (0.674; 0.699)
Rating of nurse involving you in decisions about your care: % Very good	0.48 (0.11)	0.06; 0.90	0.717 (0.706; 0.728)
Rating of nurse treating you with care and concern: % Very good	0.54 (0.12)	0.12; 0.92	0.716 (0.705; 0.727)
Confidence and trust in nurse: % Yes, definitely	0.72 (0.10)	0.28; 0.97	0.635 (0.621; 0.648)
Patient Satisfaction			
Overall experience of GP surgery: % Very good	0.47 (0.14)	0.09; 0.94	0.952 (0.948; 0.955)
Recommending GP surgery to someone who has just moved to the local area: % Yes, would definitely recommend	0.52 (0.14)	0.06; 0.96	0.962 (0.959; 0.965)
Health Status			
State of health today...mobility: % No problems in walking about	0.80 (0.06)	0.39; 1.00	0.931 (0.927; 0.935)
State of health today...self-care: % No problems with self-care	0.92 (0.04)	0.61; 1.00	0.821 (0.813; 0.829)
State of health today...usual activities: % No problems performing usual activities	0.77 (0.07)	0.33; 1.00	0.939 (0.935; 0.943)
State of health today...pain / discomfort: % No pain or discomfort	0.60 (0.08)	0.23; 0.97	0.833 (0.826; 0.841)
State of health today...anxiety / depression: % Not anxious or depressed	0.76 (0.06)	0.13; 0.95	0.643 (0.630; 0.657)
Intermediate Outcomes			
The percentage of patients with coronary heart disease in whom the last blood pressure reading (measured in the preceding 15 months) is 150/90 or less	16.99 (0.36)	0.00; 17.00	0.641 (0.624; 0.657)
The percentage of patients with coronary heart disease whose last measured total cholesterol (measured in the preceding	16.88 (0.80)	0.00; 17.00	0.603 (0.587; 0.620)

	Mean (SD)	Range	Loading* (CI95%)
15 months) is 5 mmol/l or less			
The percentage of patients with a history of TIA or stroke in whom the last blood pressure reading (measured in the preceding 15 months) is 150/90 or less	4.99 (0.18)	0.00; 5.00	0.586 (0.569; 0.603)
The percentage of patients with TIA or stroke whose last measured total cholesterol (measured in the preceding 15 months) is 5 mmol/l or less	4.96 (0.33)	0.00; 5.00	0.458 (0.438; 0.478)
The percentage of patients with hypertension in whom the last blood pressure (measured in the preceding 9 months) is 150/90 or less	56.64 (2.39)	0.00; 57.00	0.569 (0.551; 0.586)
The percentage of patients with diabetes whose last measured total cholesterol within the preceding 15 months is 5mmol/l or less	5.97 (0.23)	0.00; 6.00	0.707 (0.693; 0.721)
The percentage of patients with diabetes in whom the last IFCC-HbA1c is 75 mmol/mol (equivalent to HbA1c of 9% in DCCT values) or less (or equivalent test/reference range depending on local laboratory) in the preceding 15 months	9.43 (0.90)	0.00; 10.00	0.466 (0.445; 0.486)
The percentage of patients with diabetes in whom the last blood pressure is 150/90 or less	8.00 (0.16)	0.00; 8.00	0.739 (0.725; 0.753)
The percentage of patients on the CKD register in whom the last blood pressure reading, measured in the preceding 15 months, is 140/85 or less	10.63 (1.14)	0.00; 11.00	0.391 (0.370; 0.413)

¶ Latent variables are shown in bold.

* Loading from confirmatory factor analysis

SD, standard deviation; CI, confidence intervals; HbA1c, glycated haemoglobin; IFCC, International Federation of Clinical Chemistry; PCO, primary care organizations; GP, general practice; CHD, coronary heart disease; TIA, transient ischemic attack; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

Online Appendix 3. Alternative modelling

Following established recommendations (Hays and White 1987)¹, we tested a number of alternative similar models to better understand the associations between the different domains of quality of healthcare and to examine whether our findings were consistent with results from alternative modelling.

Five alternative models were tested in order to explore: 1) reversed causality for some of the hypothesized associations (e.g. patient satisfaction impacting on self-reported health rather than vice versa), and; 2) impact of allocating indicators into broader domains (e.g. including indicators from the domains “Access to the Practice”, “Patient Centered Care” and “Patient Satisfaction” in a single “Patient Experience” domain).

The initial alternative models failed to converge and modifications were introduced in the subsequent models with a view of optimizing parsimony and achieving convergence. Results from the alternative model that successfully converged (based on 129 observed variables providing 8514 variances and covariances and 392 parameters with 8122 degrees of freedom) are reported below.

Table S3.1. Characteristics of the healthcare quality domains considered in the alternative structural equation model.

	Source	Number of indicators	Cronbach’s α^{\dagger}	Confirmatory factor analysis (loadings range)
Structure of care*	QOF	30	0.92 (0.92;0.92)	0.33; 0.82
Clinical management	QOF	70	0.94 (0.93;0.94)	0.07; 0.63
Patient Experience**	GPPS	15	0.95 (0.94; 0.95)	0.48; 0.97
Intermediate outcomes	QOF	9	0.81 (0.77; 0.81)	0.39; 0.74
Health status	GPPS	5	0.92 (0.88; 0.93)	0.39; 0.74

[†] Mean (minimum; maximum); QOF, quality and outcomes framework; GPPS, GP Patient Survey;

* The “Structure of care” domain combines all the indicators from the “Quality Assurance”, “Education and training”, and “Medicine Management” domains included in the main model.

** The “Patient Experience” domain combines all the indicators from the domains “Patient Satisfaction”, “Access to the Practice” and four indicators of “Patient Centered Care” measuring patient-provider communication (Rating of GP listening to you; Rating of GP explaining tests and treatments; Rating of nurse listening to you; Rating of nurse explaining tests and treatments).

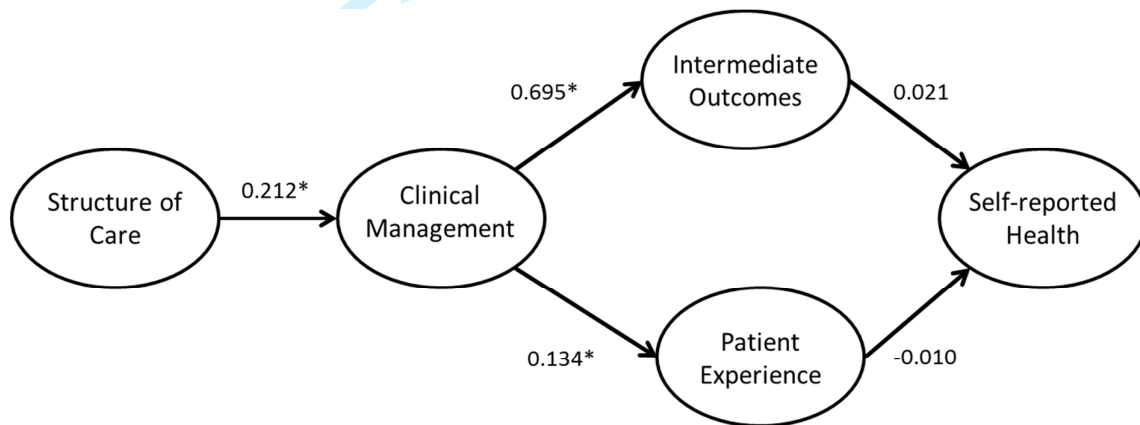
¹ Hays, R.D., White, K. 1987. The importance of considering alternative structural equation models in evaluation research. Evaluation & the health professions;10(1):90-100.

Table S3.2. Associations between healthcare quality in the alternative structural equation model.

Structural Effect/ Path coefficient	β	95 % CI	
Clinical management to Intermediate outcomes	0.695	0.680	0.711
Structure of Care to Clinical management	0.212	0.190	0.235
Clinical management to Patient Experiences	0.134	0.111	0.157
Intermediate outcomes to Health status	0.021	-0.004	0.046
Patient Experiences to Health status	-0.010	-0.034	0.013

β , standardized coefficients; CI, confidence interval

Figure S3.1. Associations between healthcare quality in the alternative structural equation model.



Goodness of Fit: The chi-squared test indicated that our model performed significantly poorer than the saturated model (likelihood ratio test of model vs. saturated: $\chi^2(8122) = 254917.3$, Prob > $\chi^2 = 0.0000$). SRMR and RMSEA values (0.07 and 0.06 respectively) suggested adequate model fit. This was however not supported by the comparative fit index (0.54), with a value below the recommended 0.9. The coefficient of determination for the whole model (with similar interpretation to R-squared) was 0.94. Equation level goodness of fit statistics showed that the model explained a high proportion of variability in “intermediate outcomes” (R-squared = 48%). However the model performed less well for “patient experience” (2%), “clinical management” (5%), and “self-reported health” (0.05%)

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Identifying pathways from quality of care to outcomes and satisfaction in
Primary Care using structural equation modelling~~Structural equation modelling~~
~~of the quality of primary healthcare in England~~

For Peer Review

ABSTRACT

Objective: To study the relationships between the different domains of quality of primary healthcare for the evaluation of health system performance and informing policy decision making.

Data Sources: ~~136~~137 quality indicators collected from 7,607 English practices between 2011-2012.

Study design: Cross-sectional study at the practice level. Indicators were allocated to sub-domains of processes of care (“quality assurance”, “education and training”, “medicines management”, “access”, “clinical management” and “patient-centered care”), health outcomes (“intermediate outcomes” and “patient-reported health status”) and patient satisfaction. The relationships between the sub-domains were hypothesized in a conceptual model and subsequently tested using structural equation modelling.

Principal Findings: The model supported two independent paths. In the first path, “access” was associated with “patient-centered care” ($\beta=0.63$), which in turn was strongly associated with “patient satisfaction” ($\beta=0.88$). In the second path, “education and training” was associated with “clinical management” ($\beta=0.32$), which in turn was associated with “intermediate outcomes” ($\beta=0.69$). “Patient-reported health status” was weakly associated with “patient-centered care” ($\beta=-0.05$), and “patient satisfaction” ($\beta=0.09$), and not associated with “clinical management” or “intermediate outcomes”.

Conclusions: This is the first empirical model to simultaneously provide evidence on the independence of all intermediate health care outcomes, patient satisfaction, and health status. The explanatory paths via technical quality clinical management and patient centeredness offer specific opportunities for the development of quality improvement initiatives.

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Key words: Primary Health Care; clinical quality; health care; patient experience; quality indicators; quality of health care; technical quality of care.

For Peer Review

BACKGROUND

Providing high-quality clinical care is a clear priority for most healthcare systems (Kocher, Emanuel, and DeParle 2010). There is a general agreement that quality of care is a complex and multidimensional construct (Donabedian 1980; Steffen 1988; Lohr, Donaldson and Harris-Wehling 1992; Bull 1994; Winefield, Murrell, and Clifford 1995; Evans et al. 2001; Harteloh 2003; Howie, Heaney, and Maxwell 2004; Cooperberg, Birkmeyer, and Litwin 2009; Gardner and Mazza 2012). One commonly accepted definition conceptualizes the quality of health care as to whether individuals can access the health structures and processes of care which they need and whether the care received is effective, thereby focusing on the domains of access and effectiveness (Campbell, Roland, and Buetow 2000). There is substantial variation in the domains proposed in the different definitions and, not surprisingly, a range of approaches have been used to measure quality of care focusing on efficiency, technical quality, patient centeredness, patient satisfaction, or health outcomes, among other (Goodwin et al. 2011).

Understanding the nature of the potential associations between these different domains of healthcare quality, and how they can help predict health outcomes has important implications for research (e.g. to inform the choice of measures) and healthcare configuration (e.g. to inform resource allocation). This issue has been the focus of a substantial number of studies. Some of them have examined the association between the quality of technical aspects of clinical care and patient satisfaction (Safran et al. 1998; Schneider et al. 2001; Gandhi et al. 2002; Chang et al. 2006; Rao et al. 2006; Sequist et al. 2008; Fenton et al. 2012; Llanwarne et al. 2013). Other studies have examined the relationship between access to healthcare and patient satisfaction (Kontopantelis, Roland and Reeves, 2010), between quality of care and health outcomes (Mold et al. 2011), between patient centeredness and satisfaction (Kinnersley et al. 1999; Paddison et al. 2015), between patient centeredness and

health outcomes (Kinnersley 1999; Shi et al. 2002), and between health outcomes and satisfaction (Alazri and Neal 2003; Marshall, Hays and Mazel 1996; Sequist et al. 2008).

The lack of consistent findings across these studies (Mead and Bower 2002; Doyle, Lennox, and Bell 2013) can be at least partially attributed to the heterogeneity among them in terms of health system organization and Primary Care orientation. Crucially, until now, research on this field has been restricted to pairwise examinations (Marshall, Hays and Mazel 1996; Schneider et al. 2001; Alazri and Neal 2003; Shi et al. 2002; Rao et al. 2006; Kontopantelis, Roland, & Reeves, 2010; Mold et al. 2011; Fenton et al. 2012; Llanwarne et al. 2013; Paddison et al. 2015) or, less frequently, the evaluation of a reduced number of domains of healthcare quality (Safran et al. 1998; Kinnersley 1999; Gandhi et al. 2002; Chang et al. 2006; Sequist et al. 2008), offering only a partial and fragmented picture of the complex network of associations between them. Simultaneously modelling the association between multiple domains of healthcare quality in a single (and large) population would address this gap, offering a more complete and comprehensive approach, testing whether the previous piecemeal approach corresponds to an empirical (not just theoretical) model, minimizing confounding and providing more valid estimations of the existing associations.

This study attempted to provide a unifying model by exploring potential relationships between various domains of care known to be markers of ‘quality’. The aim of this study was to examine the associations between the different domains of quality of primary healthcare in family (general) practices in England.

METHODS

Data sources

We conducted a cross-sectional study using data from English family practices. In England family practices are the places where general practitioners (GPs) work. They usually work as part of a team which includes nurses, healthcare assistants, practice managers, receptionists and other staff. The vast majority of the population is registered with a family practice for the provision of primary care services which are free at the point care. Computerization is almost complete (with electronic medical records operating in the vast majority of the practices) and driven by participation in the profitable the Quality and Outcomes Framework (QOF), a national pay-for-performance scheme (Roland 2004).

Data on indicators for quality of the healthcare provided by family practices in England for the financial year 2011-2012 was obtained from reporting systems for two major quality improvement initiatives in primary care in England: the QOF (Roland 2004), and the GP Patient Survey (GPPS) (Campbell et al. 2009).

QOF is a voluntary scheme that financially rewards practices for their performance across a range of quality indicators. In the financial year 2011-2012 it included a total of 141 indicators. QOF data can be obtained from the Quality Management and Analysis System (QMAS), which automatically extracts data from the clinical record systems of practices. For each QOF indicator practices accumulate points according to their level of achievement, each point being associated with a financial benefit.

The GPPS is a survey capturing the experiences of patients who have been continuously registered with a practice for at least 6 months. This survey includes 46 questions, and is mailed each year to 2.7 million patients. 246 indicators of quality of care as perceived and self-reported by patients are derived from the survey. Each indicator depends on the percentage of patients from a practice giving a specific answer to an item in the survey

(e.g., percentage of patients rating their experience of their GP surgery as “very good”). The overall mortality-adjusted response rate was 40% for the 2011-2012 year. Additional details of the survey are available elsewhere (Campbell et al. 2009).

All the data above described was extracted from the Health & Social Care Information Centre (Health and Social Care Information Centre 2015).

Study sample

The dataset contained a total of 8,433 practices (99% of all practices in England). Of these, 310 practices did not contain QOF data, and 99 had no data relating to GPPS (possibly on account of merging and reconfiguring of practices within the data collection timeframe relevant to this study) and were excluded. Thirteen practices were also excluded because they offered only non-standard services (e.g. walk in services, addiction services) or have skewed patient populations (e.g. only care home or university students). Additionally 404 practices had incomplete data on some GPPS indicators (most frequently on the indicator measuring “frequency of seeing preferred GP”) and were excluded, leaving 7,607 practices in the final dataset (91.2% of all practices in England). Generally, the 404 practices excluded due to incomplete data in some GPPS indicators were very similar (according to the data extracted about their characteristics) to those that remained included.

Development of the conceptual model

A conceptual model was developed to describe hypothesized relationships between the different domains of quality of healthcare and health outcomes. The model, based on the conceptualization of quality of healthcare proposed by Donabedian (Donobedian 1966), was developed in an iterative process started by two members of the research team, and subsequently reviewed and approved by the all members of the team. We operationalized

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3 fundamental domains for quality of care relating to structure (access), processes of care
4 (clinical management, person centeredness), and outcomes (intermediate outcomes, health
5 status, and patient satisfaction); and hypothesized the relationships between them (see Online
6 Appendix 1). Subsequently we examined all the indicators available in the two datasets, and
7 allocated them to the putative domains of quality, adding domains where a homogeneous set
8 of indicators measuring a distinct area of quality was not covered by existing domains.
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10 Indicators that did not offer information for any of the fundamental domains were not
11 included in the study. Although not originally a criterion for the identification of domains, the
12 resulting domains exclusively contained indicators from one of the two data sources, but not
13 both. The allocation of QOF indicators to each of the domains was to a large degree based on
14 the indicators' classification produced by the National Institute for Health and Care
15 Excellence (Prescribing and Primary Care team, Health and Social Care Information Centre
16 2012). The allocation of GPPS indicators was based on previous work that identified a set of
17 composite markers that summarize the different aspects of the survey (Sizmur 2012).
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34 For items in the GPPS we selected those indicators retaining the maximum amount of
35 information based on the distribution of the scores at practice level (i.e., the indicators
36 corresponding to the response category most frequently selected by respondents). These were
37 consistently those capturing the most positive healthcare experience (e.g., 'very good'
38 experience of making an appointment as opposed to other potential responses to that item).
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40 Finally, "health status" indicators were obtained from the responses to the EQ-5D (Brooks
41 1996), a standardized measure of health outcomes that was administered as part of the GPPS.
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50 As part of its development process, the model was redefined because of inadequate
51 fit. This was undertaken based on clinical and statistical criteria, and consisted in removing
52 from the model the latent variables "records and information" (mostly related to information
53 systems), and "overall structure" (accounting for key structural characteristics of the
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practices). The final model included the following nine domains (~~136~~¹³⁷ indicators): quality assurance (16), education and training (6), medicine management (8), access to the practice (~~89~~), clinical management (70), patient-centered care (12), patient satisfaction (2), intermediate health outcomes (9), and health status (5). The complete list of indicators used to measure each of the domains is available in the Online Appendix 2.

Statistical analysis

We used a hybrid structural equation model (SEM) combining factor and path analysis (Kline and Santor 1999) to empirically test the associations between the quality domains hypothesized in the conceptual model.

Prior to analysis, an assessment of model identification was made using the two-step rule (Bollen 1989). Latent variables were constructed to measure each of the quality domains based on the indicators allocated to each of them. The suitability of the allocation of each indicator to its corresponding domain was examined based on their loadings after confirmatory factor analysis and their internal consistency (Cronbach’s alpha). A correlation matrix for all the latent variables was subsequently constructed. Finally the association between domains was tested with path analysis.

Statistical analysis comprised the estimation of non-standardized and standardized coefficients for the conceptual model (using the maximum likelihood estimator) and assessments of model fit (assessment of Chi-squared (Kline 2015), Standardized Root Mean Squared Residual (SRMR) (Kline and Santor 1999), Comparative Fit Index (Hoyle 1995), Root Mean Squared Error of Approximation (RMSEA), and equation-level goodness of fit).

We needed to redefine the model because of inadequate fitness. This was done based on clinical and statistical criteria and consisted in removing from the model the latent variables “records and information” (mostly related to information systems based on alerts),

and “overall structure” (accounting for all the structural characteristics of the practices that would affect healthcare quality). Once an adequate model was successfully identified, we tested a number of alternative similar models to better understand the associations between the different domains and to examine the consistency of our findings against different data modelling approaches (Hays and White 1987). More specifically, five alternative models were tested in order to explore: 1) reversed causality for some of the hypothesized associations (e.g. patient satisfaction impacting on self-reported health rather than vice versa), and; 2) impact of allocating indicators into broader domains (e.g. collapsing the domains “quality assurance”, “education and training”, and “medicine management” into a single “structure of care” domain). The initial alternative models failed to converge and modifications were introduced in the subsequent models with a view of optimizing parsimony and achieving convergence.

All analyses were carried out in Stata v12.1 and we used an alpha level of 5% throughout.

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RESULTS

General characteristics of the practices are presented in Table 1. According to the NHS Patient Register, the number of patients registered with the practices in this study during the study period was 54,299,945 (mean number of patients per practice: 7,084 (standard deviation (SD) = 4,144).

[TABLE 1 ABOUT HERE]

Cronbach’s α and confirmatory factor analysis loadings indicated adequate internal consistency and structural validity of all the nine final domains (Table 2).

[TABLE 2 ABOUT HERE]

The matrix of correlations between the domains is shown in the Table 3. The highest correlations were observed for the pairs “patient-centered care” and “patient satisfaction” ($r=0.88$), “clinical management” and “intermediate outcomes” ($r=0.69$), and “medicine management” and “education and training” ($r=0.67$). The highest correlation coefficient for “health status” was with “patient satisfaction” ($r=0.05$) and “patient-centered care” (-0.05).

[TABLE 3 ABOUT HERE]

Figure 1 shows the results of the final model used to examine the associations between the quality domains (confidence intervals available in Table 4). The 137 observed variables provided 9590 variances and covariances, and the model estimated contained 432 parameters with 9158 degrees of freedom. We report standardized coefficients, which can be interpreted as standard regression coefficients and that allow for direct comparison (e.g. a one

SD increase in “education and training” is associated with a 0.32 SD increase in “clinical management”, but with a smaller 0.09 SD increase in “patient-centered care”).

[TABLE 4 ABOUT HERE]

According to the magnitude of the standardized coefficients, the model suggested two distinct paths. In the first path, “access to the practice” was associated with “patient-centered care” ($\beta=0.63$), which in turn was strongly associated with “patient satisfaction” ($\beta=0.88$). In the second path, “education and training” was associated with “clinical management” ($\beta=0.32$), which in turn was strongly associated with “intermediate outcomes” ($\beta=0.70$). These two paths were substantially independent, with weak associations between “clinical management” and “patient-centered care” ($\beta=0.08$), and between “clinical management” and “patient satisfaction” ($\beta=0.05$). Finally, “health status” was weakly associated with “patient-centered care” ($\beta=-0.05$), and “patient satisfaction” ($\beta=-0.09$), but not with “clinical management” or “intermediate outcomes”.

[FIGURE 1 ABOUT HERE]

The chi-squared test indicated that the model performed significantly poorer than the saturated model (likelihood ratio test of model vs. saturated: $\chi^2(9158)=296452.6$, $\text{Prob}>\chi^2 = 0.000$). However this test is sensitive with very large sample sizes and alternative measures (SRMR and RMSEA, with values of 0.07 and 0.06 respectively) indicated adequate model fit (SRMR and RMSEA values (0.07 and 0.06 respectively) suggested adequate model fit (Steiger 1990). This was however not supported by the comparative fit index (0.58), with a value below the recommended 0.9. The coefficient of

determination for the whole model (with similar interpretation to R-squared) was 0.99. Equation level goodness of fit statistics showed that the model explained a high proportion of variability in “patient satisfaction” (R-squared =78%), “intermediate outcomes” (48%), and “patient-centered care” (42%). However the model performed less well for “clinical management” (13%) and “health status” (0.3%).

Only one of the five alternative models considered successfully converged. The results from this alternative model (available in Online Appendix 3) generally supported our main findings, observing positive associations between “structure of care” (derived from indicators from the sub-domains “quality assurance”, “education and training” and “medicine management”) and “clinical management”, which in turn was associated with “intermediate outcomes” and with “patient experience” (derived from indicators from “access to practices”, “patient centeredness”, and “patient satisfaction”). Self-reported health was not associated with patient experience or with intermediate outcomes.

DISCUSSION

In this study we used a structural equation model to examine the network of associations between multiple domains of the quality of healthcare provided in family practices in England. We identified two independent paths. The first path links access to practices to patient-centered care and to patient satisfaction. The second path links education and training to clinical management of care and to intermediate outcomes. Patient reported health status was very weakly associated with patient-centered care and patient satisfaction, and not associated with clinical management or intermediate outcomes.

Strengths and limitations

This study has a number of strengths. It includes data for the great majority of QMAS practices in England (covering over 99% of patients). In addition it simultaneously examines the association between multiple domains of healthcare quality by using robust analytic methods and a large number of evidence-based indicators which rely on information provided both by clinicians and patients. But some limitations need to be taken into account. First, the cross-sectional nature of this study makes causal inference problematic. Reversed associations are implausible in most of the cases, but not always (e.g. we hypothesized intermediate outcomes to affect patient satisfaction, but inversed causality is also plausible as more satisfied patients could be more adherent to treatment recommendations, which could result in better intermediate outcomes). Future research using longitudinal designs is needed to better model causal effects. Second, following established recommendations (Hays and White 1987) we considered a number of alternative structural equation models to better understand the associations between the different domains of quality of healthcare tested in our main model. However only one of them could be successfully estimated (which generally supported our main findings), and we cannot rule out the possibility of other alternative

models leading to a different interpretation of our data. Third, our study was restricted to practice-level analysis and did not allow us to draw conclusions about patient-level associations. Practice level analysis, however, is of inherent interest and can inform relevant aspects such as resource allocation and primary care configuration. Four, data for this study was obtained from two different sources, and each quality domain was based on information from only one of them. This could have resulted in an overestimation of the magnitude of the associations between domains from the same source, and an underestimation of the associations from different sources. Fifth, although we used established measures of family practice quality in England, some limitations intrinsic to both sources may have affected our findings. Concerns relating to a low response rate and low reliability have been raised with respect to the GPPS. However, there is little evidence that low response rates have introduced bias (Campbell et al. 2009), and research shows that most survey questions used in this study meet stringent guidelines for reliability (Lyratzopoulos et al. 2011). QOF indicators measure only a fraction of the healthcare provided by a practice to their patients, and the analysis of other (non-incentivized) activities might yield different results. Finally, the model did not include practice characteristics such as deprivation or size that have been previously associated with performance. A decision was made not to include those additional variables to facilitate model convergence. Similarly, it would have been desirable to include in the model hospital admissions or mortality rates, but this information was not readily available.

Interpretation of results and implications for health services organization

The first path suggests that patients’ ease of access to their practice is associated with patient-centered care, and that patient satisfaction is higher in those practices with higher levels of patient-centered care. The observed relationship between access and patient-centered care may suggests that, by enhancing access, practices may create a platform from which to

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3 develop opportunities for a partnership between patient and clinicians that accounts for the
4 patient's position and feelings. This would support the idea of prioritizing resources for
5 improving access to family practices. The observed relationship between patient-centered
6 care and patient satisfaction has been reported previously (Kinnersley et al. 1999; Lewin et al.
7 2001) and has strong face validity. A recent patient level study including more than 2 million
8 patients responding to the GP Patient Survey observed that doctor communication was the
9 most important patient experience factor driving satisfaction (Paddison et al. 2015).

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12 The second path identified suggests that practices with higher levels of training and
13 education are better equipped to deliver high quality clinical care, having a more positive
14 impact on intermediate health outcomes. This finding has strong face validity, and supports
15 the clinical aspects that are incentivized as part of QOF scheme in the UK. In addition, it
16 highlights the importance of adequate training, identifying it as a priority area for resource
17 allocation. Interestingly however, although the education and training provided to healthcare
18 professionals was associated with better clinical management, its association with patient-
19 centered care was very weak. This suggests that current training initiatives might have a very
20 strong clinical orientation, in line with observations from previous research (Tsimtsiou et al.
21 2007). An increased focus on patient-centered education (which could be achieved for
22 example by involving patients in training programs, which have shown to produce sustained
23 gains in levels of interpersonal skills (Greco, Brownlea, and McGovern 2001)), may
24 represent an opportunity of quality improvement worth exploring.

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27 We observed a weak positive association between clinical management and patient-
28 centered care and satisfaction, which was stronger in our alternative model. Previous studies
29 analyzed the relationship between clinical management and patient experiences in primary
30 care settings, reporting findings ranging from no association (Gandhi et al. 2002; Chang et al.
31 2006; Rao et al. 2006) to modest positive associations (Schneider et al. 2001; Sequist et al.

2008; Llanwarne et al. 2013). Studies in secondary care reported moderate (Lehrman et al. 2010) or strong (Jha et al. 2008; Isaac et al. 2010; Stein et al. 2014) positive associations. The positive association observed in our study does not support the idea that encouraging doctors to concentrate on technical aspects of care, incentive schemes such as the QOF will lead to deterioration in the doctor-patient relationship, or vice versa.

Unexpectedly, medicine management was negatively associated with clinical management. Although it may be hypothesized that adequate medicine management may be resource consuming and it may occur at the expense of high quality processes of care, there is little evidence to support such a view. We are therefore unable to explain the observed association, and more research is needed to confirm this inverse relationship and eventually elucidate the mechanisms by which it might operate.

Although patient-reported outcome measures have been traditionally regarded as a measure of need rather than performance, in recent years there has been a growing interest in their use for performance assessment of the health system and for benchmarking and quality improvement purposes in healthcare organizations (Nelson et al. 2015). In our study, self-reported health status was very weakly associated with patient-centered care, and we observed no association with clinical management or intermediate outcomes. Similar findings were observed in our alternative model. Our findings are consistent with a previous study which observed no association between patients' baseline assessments of the quality of primary care they received and subsequent changes in health-related quality of life and survival (Mold et al. 2011). However this contrasts with previous primary care specific studies supporting a link between primary care supply and positive perceived health (Shi et al. 1999; Shi and Starfield 2000; Shi and Starfield 2001). More specifically it has been observed that good primary care experience, in particular enhanced accessibility and continuity, is associated with better self-reported health both generally and mentally (Shi et

al. 2002). A number of aspects need to be taken into account when interpreting the lack of association observed in our study. First, the fact that we used self-reported health status aggregated at the practice level may have reduced our ability to detect a potential association. An individual patient receiving good quality of primary healthcare is more likely to have better health outcomes than a patient receiving poor primary healthcare. However the same does not necessarily apply at the practice level, as measures of population health are more likely to be influenced by environmental and social factors. Second, the potential impact of processes of care on health outcomes is likely to occur in a longer period of time than, for example, the impact of processes of care on patient satisfaction or intermediate outcomes. The cross-sectional nature of our study thus hindered our ability to examine this specific relationship. Finally, it is well known that health status is correlated with multiple factors beyond the GP's control. This include genetic variation (it has been estimated that one-third of the variability of self-reported health can be attributed to genes (Romeis et al. 2000)), but also by other personal, social, economic, and environmental factors (Dahlgren and Whitehead 1991), which were not included in our study. Therefore a hypothetical small effect such as the one described by Shi et al. (2002) cannot be ruled out by the findings of this study because of the methodological constraints described above. Although we think our model is of relevance in reflecting the status of the healthcare system, we acknowledge that it may be of more limited value in reflecting health.

Self-reported health status was weakly associated with patient satisfaction, which supports previous research from the hospital setting (Hays et al. 2006). An inverse association may be plausible in this case (more satisfied patients could have higher adherence to treatment recommendations and therefore have better health outcomes), and has been observed in a previous longitudinal study (Marshall, Hays and Mazel 1996). However we tested this inverse association in our alternative model, observing that patient experience was

not associated with self-reported health. Our results might reflect that patients with poorer health constitute a particular group of primary care service users not only in respect of above-average service use, but also in respect of the range and type of services used, particularly reflective of lower levels of overall satisfaction with healthcare services. This is in line with a recent study observing that patients with multimorbidity more frequently report worse experiences in primary care (Paddison et al. 2015). This could have implications for quality improvement initiatives, as segmenting the patient population by their medical needs could enable patients' feedback to indicate where quality improvements are required for specific groups. Other industries have been successful in understanding where to make improvements for consumers through data segmentation techniques that identify specific groups within the population (Flott et al. 2016).

Conclusion

By including an unprecedented number of factors within a single statistical model, this study was able to describe the network of associations between multiple domains of quality of healthcare provided in Primary Care in England. This is the first empirical model simultaneously providing evidence on the independence of all intermediate health care outcomes, patient satisfaction, and health status. The explanatory paths via technical quality clinical management and patient centeredness offer specific opportunities for the development of quality improvement initiatives. Further longitudinal and patient level studies are needed to confirm our findings.

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For Peer Review

Table 1. Characteristics of General Practices included in the study (N=7,607)

	Mean (SD)	Range
Number of registered patients	7,084 (4144)	597; 44,071
Female	50.37 (5.59)	20.28; 75.47
Age (%)		
18-24 years	9.83 (5.66)	0; 86.17
25-34 years	17.49 (8.19)	0; 70.07
35-44 years	18.43 (5.20)	0; 44.87
45-54 years	18.32 (4.11)	0; 37.42
55-64 years	15.02 (4.43)	0; 32.92
65-74 years	11.20 (4.25)	0; 28.44
75-84 years	6.95 (2.99)	0; 21.56
≥85 years	2.75 (1.61)	0; 11.62
Race (%)		
White	84.24 (21.90)	0; 100
Black	3.26 (6.54)	0; 64.13
Asian	8.25 (14.61)	0; 93.56
Index of multiple deprivation*	23.52 (12.08)	2.86; 66.38

*McLennan et al. 2011. The English Indices of Deprivation 2010: Technical Report. 2011.

Table 2. Characteristics of the healthcare quality domains considered

	Source	Number of indicators	Cronbach's α [†]	Confirmatory factor analysis (loadings range)
Education and training	QOF	6	0.72 (0.67; 0.72)	0.47; 0.65
Medicines management	QOF	8	0.84 (0.80; 0.85)	0.35; 0.87
Quality assurance	QOF	16	0.86 (0.85; 0.86)	0.30; 0.76
Access to the practice	GPPS	8	0.92 (0. 90; 0.92)	0.49; 0.99
Clinical management	QOF	70	0.94 (0.93;0.94)	0.07; 0.63
Patient-centered care	GPPS	12	0.97 (0.96; 0.97)	0.64; 0.97
Patient satisfaction	GPPS	2	0.96 (NA)	0.95; 0.96
Intermediate outcomes	QOF	9	0.81 (0.77; 0.81)	0.39; 0.74
Health status	GPPS	5	0.92 (0.88; 0.93)	0.39; 0.74

[†] Mean (minimum; maximum); QOF, quality and outcomes framework; GPPS, GP Patient Survey; NA: Not applicable

Table 3. Correlations between the healthcare quality domains

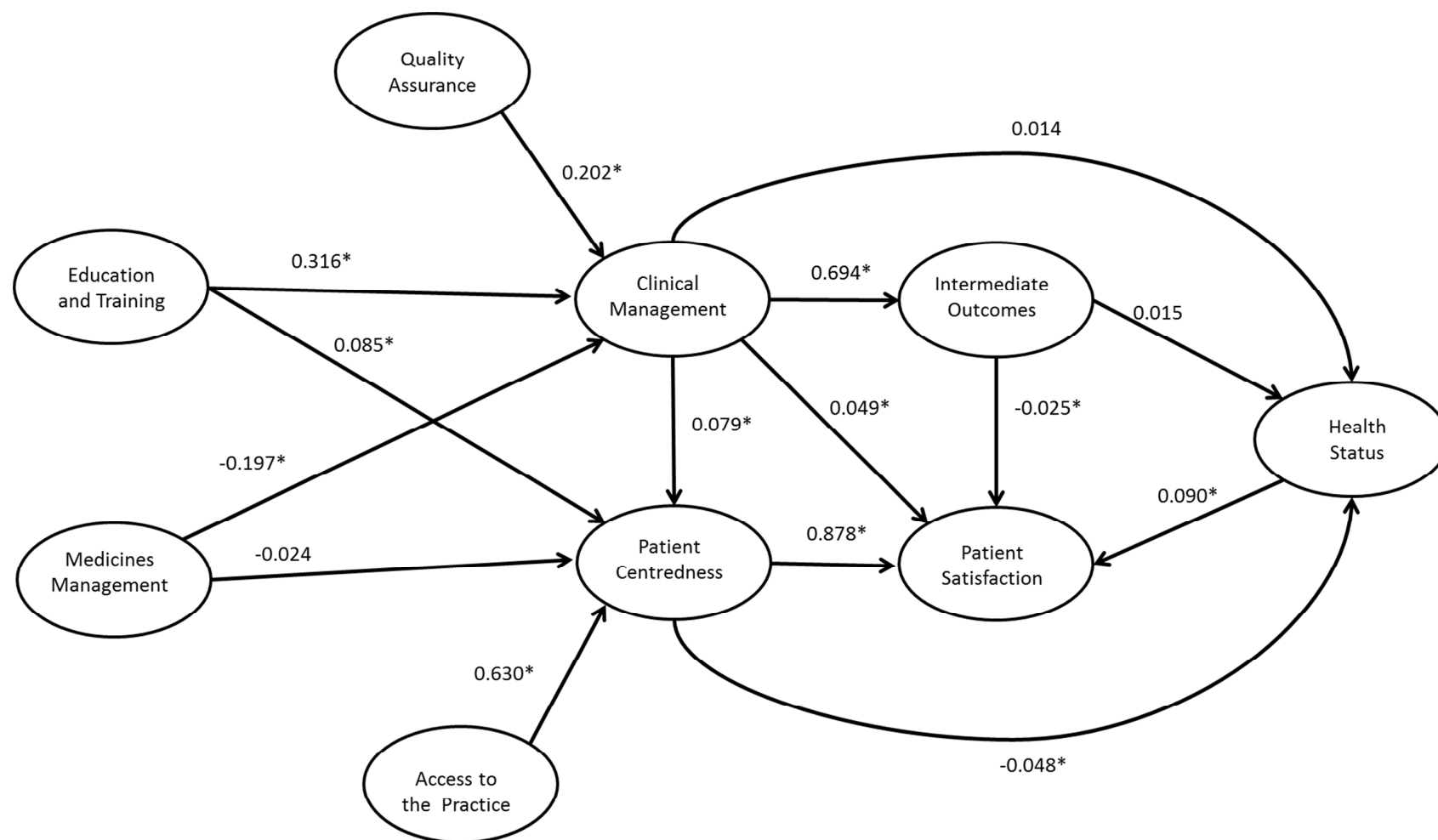
	Quality assurance	Education and Training	Medicines Management	Access to the practice	Clinical management	Patient-centred care	Intermediate Outcomes	Patient Satisfaction	Health Status
Quality assurance	1	0.634	0.605	0.026	0.284	0.078	0.197	0.078	0.003
Education and Training	0.634	1	0.670	0.026	0.313	0.110	0.217	0.107	0.021
Medicines Management	0.605	0.670	1	0.018	0.138	0.056	0.095	0.053	0.001
Access to the practice	0.026	0.026	0.018	1	0.010	0.632	0.067	0.553	-0.030
Clinical management	0.284	0.313	0.138	0.010	1	0.109	0.694	0.129	0.019
Patient-centred care	0.078	0.110	0.056	0.632	0.109	1	0.076	0.878	-0.045
Intermediate Outcomes	0.197	0.217	0.095	0.067	0.694	0.076	1	0.077	0.020
Patient Satisfaction	0.078	0.107	0.053	0.553	0.129	0.878	0.077	1	0.051
Health Status	0.003	0.021	0.001	-0.030	0.019	-0.045	0.020	0.051	1

Table 4. Associations between healthcare quality in the final structural equation model.

Structural Effect/ Path coefficient	β	95 % CI	
Patient-centered care to Patient satisfaction	0.878	0.872	0.885
Clinical management to Intermediate outcomes	0.694	0.678	0.709
Access to practice to Patient-centered care	0.630	0.616	0.644
Education and training to Clinical management	0.316	0.272	0.360
Quality assurance to Clinical management	0.202	0.166	0.238
Medicines management to Clinical management	-0.197	-0.236	-0.158
Health status to Patient satisfaction	0.090	0.077	0.103
Education and training to Patient-centered care	0.085	0.052	0.118
Clinical management to Patient-centered care	0.079	0.060	0.099
Clinical management to Patient satisfaction	0.049	0.030	0.068
Patient-centered care to Health status	-0.048	-0.071	-0.024
Intermediate outcomes to Patient satisfaction	-0.025	-0.045	-0.006
Medicines management to Patient-centered care	-0.024	-0.053	0.006
Intermediate outcomes to Health status	0.015	-0.024	0.053
Clinical management to Health status	0.014	-0.023	0.050

β , standardized coefficients; CI, confidence interval

Figure 1. Associations between healthcare quality and health outcome domains. Results from the final structural equation model.



Statistically significant associations ($p < 0.05$) are noted with an asterisk (*).

Responses to reviewers

Reviewer #1

The authors were very responsive to the original reviews. My remaining concern is about the alternative structural equation model. The paper notes that five alternative models were evaluated but there were problems with convergence. One model is presented as online Appendix 3 and referred to in the text of the paper. This model is similar to one I suggested. When I tried to fit the model I specified in my previous review in STATA (reading in the correlations reported in Table 3) convergence was not achieved. The problem with convergence was due to the extremely high correlation between what the authors called patient-centered care and the patient satisfaction variable (0.878). The program had trouble because patient-centered care wanted to load around 1.00 and, therefore, the error term was around 0.00. When I ran the model using SAS PROC CALIS it converged but provided a factor loading greater than 1.00 and a negative error variance for patient-centered care. Despite the problems with convergence and out-of-bound estimates, the parameter estimates were generally similar to what the authors reported in Figure S3.1. However, the authors reported a CFI of 0.54 while the CFI estimate from SAS was 0.97. Because of the out-of-bounds estimates, I also specified a model that included access, patient-centered care, and patient satisfaction as observed variables without a latent variable for these three observed variables. That model also fit the data well and showed significant direct effects of clinical management on access, patient-centered care, and patient satisfaction.

We would like to thank the Reviewer for replicating our analyses and exploring additional models. It is very reassuring that the Reviewer's own modelling using an alternative statistical package provided similar results to our own. The out of bonds estimates in their proposed modelling limit the validity of the results and renders the discrepancy in CFI estimates difficult to interpret.

In relation to the model specifying three variables as observed variables rather than latent variables, we are unsure whether or not the reviewer is suggesting us exploring its suitability as an additional alternative model. Additional modelling would increase the complexity of the presentation and interpretation of the results and is unlikely to add value to the results of the models already included the paper. In addition, we support the view that the domains should be measured using latent variables, rather than observed variables, since we are using data from multiple indicators, which do not necessarily provide in themselves a comprehensive measurement of the construct. However, if the reviewer and the editorial team are not fully satisfied with the revision and rationale, we will be very happy to consider how best to include the proposed new modelling. In that case we would need details related to the full specification of the proposed modelling in order to enable replication and evaluation of its performance and results.

To help readers verify that they understand the models being tested, the authors should report the chi-squares and dfs for the models, and include text that indicates that 9 observed variables provide 45 variances/covariances to work with and (e.g., the alternative model) and 20 parameter estimates were made (yielding 25 dfs).

Thank you for the suggestion. We have now included the requested information for both the main and alternative models.

"The 137 observed variables provided 9590 variances and covariances, and the model estimated contained 432 parameters with 9158 degrees of freedom." (Results, page 11)

"The chi-squared test indicated that the model performed significantly poorer than the saturated model (likelihood ratio test of model vs. saturated: $\chi^2(9158)=296452.6$, $Prob>\chi^2 = 0.000$). However this test is sensitive with very large sample sizes, and alternative measures (SRMR and RMSEA, with values of 0.07 and 0.06 respectively) indicated adequate model fit (Steiger 1990)." (Results, page 12)

“Results from the alternative model that successfully converged (based on 129 observed variables providing 8514 variances and covariances and 392 parameters with 8122 degrees of freedom) are reported below.” (Online Appendix 3, page 1)

“The chi-squared test indicated that our model performed significantly poorer than the saturated model (likelihood ratio test of model vs. saturated: $\chi^2(8122) = 254917.3$, $Prob > \chi^2 = 0.0000$). (Online Appendix 3, page 3)

Reviewer #2

I have no additional comments. The authors have adequately dealt with my concerns.

Thank you for the positive feedback on the revised manuscript.