European Journal of Public Health, Vol. 24, No. 6, 1004–1009
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doi:10.1093/eurpub/cku011 Advance Access published on 17 February 2014

Reproducibility of diabetes quality of care indicators as reported by patients and physicians

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Introduction: Self-report of diabetes care has moderate validity and is prone to under- and over-reporting. We assessed reproducibility of a range of processes and outcomes of diabetes care as reported by patients and physicians. **Methods:** In a Swiss community-based survey, patients with diabetes and physicians independently reported past 12 months processes of care (HbA1c, lipids, microalbuminuria, blood pressure, weight, foot and eye examinations) and last measured values of HbA1c, height, weight and blood pressure. For dichotomous variables, we assessed reliability by Cohen's kappa and agreement by uniform kappa. For continuous measures, we used Lin's concordance correlation coefficient and limits of agreement, respectively. **Results:** Mean age of the 210 patients was 65 years; 40% were women, and 51% had diabetes for >10 years. Agreement was good for recommended processes of care such as blood pressure (uniform kappa = 0.94), HbA1c (0.93), weight (0.88) and lipid (0.78), but lower for microalbuminuria, foot and eye examinations (all <0.50). Cohen's kappa values were all low (<0.25). Comparisons of reported continuous variables showed large limits of agreement for height (±6 cm) and weight (8–10 kg) despite high concordance correlation coefficients (0.93 and 0.97). Concordance correlation coefficients were smaller for HbA1c (0.72) and blood pressure (0.5–0.6), with large limits of agreement (±2% and ±25 mmHg). **Conclusion:** While agreement of routine processes of care was good, agreement was less satisfactory for microalbuminuria, foot and eye examinations. Reports of continuous outcomes yielded good reliability but too wide limits of agreement. Quality of care evaluation relying on self-report only should be made cautiously.

Introduction

Chronic disease care requires good collaboration between health care providers, teamwork, self-management education and use of evidence-based medicine.[1] However, chronic care is a complex process often shown to be suboptimal.[2–4] Diabetes, a major public health burden in terms of morbidity, disability and mortality,[5] is not an exception, and improving quality of diabetes care is needed to reduce the health and societal burden of this disease.[6]

Self-report of processes and outcomes of care is often used as a source of information. Indeed, health care providers sometimes need to rely on patient self-report for their monitoring, especially in health care settings lacking shared electronic health records. In addition, self-report is used in community-based surveys, as it is an easier means of collecting data than examination-based surveys.

Self-report of diabetes-specific data has been shown to present moderate validity and be prone to both under- and over-reporting.[7–10] However, studies assessing the validity of self-reported diabetes measures have frequently only focused on a small number of indicators, such as foot and eye examinations[10] or levels of glycosylated haemoglobin (HbA1c).[8] To our knowledge, assessment of reliability and agreement has not been conducted on a range of process and outcome indicators of care. A targeted evaluation of more indicators may help define whether some may be more suitable for self-report in future surveys.

Within the context of a regional diabetes program in Switzerland, we conducted a community-based survey to first characterize patients with diabetes who were living in that region and second assess the quality of their care.[11] We aimed to evaluate reproducibility of quality of care indicators, by comparing reliability and agreement of diabetes-related processes and outcomes of care, as independently reported by patients and their physicians.

Methods

Study design and population

Within the development and implementation of a regional diabetes management program, a community-based cross-sectional survey was conducted in the fall of 2011 in the canton of Vaud, a Swiss state of >700 000 inhabitants.[12] Briefly, a random sample of registered community pharmacies were contacted and asked to recruit consecutive adults visiting the pharmacy with a diabetes-related prescription.[11] Non-institutionalized adults with type 1 or 2 diabetes for at least 12 months were invited to participate when visiting the pharmacy with a prescription for insulin, oral hypoglycaemic drugs, glycaemic strips or a glucose meter. Women with current gestational diabetes, patients not fluent enough in French to fill in the questionnaire or unable to give informed consent were excluded. All participating patients gave written informed consent for their involvement in the study and for contacting their treating physicians. This study was approved by the state institutional review board.

Collected data

Patients filled in a paper questionnaire with the following self-reported data: age, gender, education (primary, secondary, high school/university), civil status, smoking status (current, former,

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non-smoker), characteristics of diabetes (type, treatment, duration, complications), and comorbid conditions (heart failure, valvulopathy, hypertension, hyperlipidaemia, chronic respiratory conditions, peptic ulcer, osteoporosis, osteoarthritis, Parkinson disease, malignancy, depression, other chronic condition). Recommended process of care measures[6] reported during the past 12 months were also collected: HbA1c (possible answers: not done, done once, done several times, unknown whether test was performed or not), lipid profile (not done, done, unknown whether test was performed or not), urine analysis for microalbuminuria (not done, done, unknown whether test was performed or not), foot examination (not done, done, unknown whether it was performed or not), eye examination by ophthalmologist (done in past 12 months, in past 12–24 months, >24 months before, never done, unknown whether it was performed or not), blood pressure (not done, done, unknown whether it was performed or not), weight measurement (not done, done, unknown whether it was performed or not) and influenza immunization (not done, done, unknown whether it was performed or not). Patients were also asked to report, if known, the last measured value of HbA1c, height, weight, systolic and diastolic blood pressure.

We then contacted treating physicians (i.e. the physician taking care of patient's health, as reported by the patient) to fill in paper report cards. In addition to some personal characteristics (physician's age, gender, rate of part-time work, board-certified specialty, practice location and type), physicians reported the following data from patient medical charts: dates and last measured values of HbA1c, height, weight and blood pressure, as well as the dates of last foot and eye examination, urine analysis for microalbuminuria, lipid profile and influenza immunization.

Patient- and physician-reported process of care measures were dichotomized into done or not done during the past 12 months. 'Unknown whether test was done or not' responses, which represented generally less than a few percents of the answers, were recoded as missing. For continuous outcomes of care, both patients and physicians were asked to report the respective last values, emphasizing the referral to the last encounter or measure.

Statistical analyses

We first performed simple descriptive statistics of collected variables and then assessed reproducibility between patients' and physicians' reports. Following de Mast[13] and Brennan,[14] we used Cohen's kappa[15] and uniform kappa[13] as reliability and agreement parameters, respectively, for dichotomous process indicators. As sample sizes were small and the marginal distributions of the dichotomous variables rather asymmetric, a Bayesian version of Cohen's kappa was also computed,[16] as it appears to be more appropriate in such situations. For continuous outcome results, we used Lin's concordance correlation coefficient[17] as a measure of reliability and Bland & Altman's 95% limits of agreement[18] to assess measurement error (agreement). Because limits of agreement need to be clinically interpreted, deciding on whether or not agreement is good must take into account the clinical context. For comparison purposes with other studies, we also computed raw agreement, defined as the raw or unadjusted percentage of agreement in a 2×2 table.

Finally, we conducted exploratory stratified analyses to assess whether reproducibility was associated with patient's age (<65 vs. ≥65 years), gender, diabetes type (type 1 vs. type 2 and undetermined type of diabetes), comorbid conditions (none, one, >1), education (primary, secondary, high school/university) or physician's specialty (endocrinologist vs. other) and clinical setting (solo private practice vs. other). We assessed whether there was a statistically significant difference between the strata reliability and agreement parameters by determining whether confidence intervals overlapped. All analyses were performed using Stata 12 (StataCorp, College Station, TX) and WinBUGS (MRC Biostatistics Unit, Cambridge, UK) for the Bayesian approach.

Results

Eight hundred nine of the 1013 consecutive eligible patients visiting pharmacies agreed to participate, of which 406 (50%) returned a filled questionnaire. Out of 186 contacted physicians whose contact details were given by patients, 111 (60%) sent back report cards for a total of 210 patients. Mean age of the 210 patients, for whom we had both patient and physician data, was 65.4 years, and 40% were women (Table 1). Type 1 and 2 diabetes was reported by 13.8 and 66.7%, respectively, while diabetes type remained undetermined for nearly 20% of the patients. Half of patients had diabetes for >10 years and half were treated without insulin. Treating physicians were aged 53.5 years on average, and 18% were women (Table 1). About three quarters were general internists and 16% endocrinologists; a majority worked in solo private practices.

Process and outcome of care indicators, as reported independently by patients and physicians, were almost identical, except for foot examination and influenza immunization (Table 2). For these latter two processes of care, physicians' reported data showed more missing values and appeared slightly better than when considering patients' reported data.

Comparisons of diabetes-related process indicators in the past 12 months, as reported by patients and physicians, yielded contrasting results (Table 3). Agreement was good for routine processes of care like measurement of blood pressure [uniform kappa ($\kappa_U = 0.941$], HbA1c ($\kappa_U = 0.932$), weight ($\kappa_U = 0.882$) and lipid profile ($\kappa_U = 0.780$), but it was less satisfactory for procedures such as microalbuminuria, and foot and eye examinations (all $\kappa_U < 0.500$). Cohen's kappa values were generally very low (all <0.25), as expected, as cells in the 2×2 tables were not homogenously filled, thereby implying low reliability (i.e. difficulty to discriminate). Bayesian estimates of Cohen's kappa differed substantially from the standard Cohen's kappas.

Means of continuous outcomes were similar regardless of whether they were reported by patients or physicians (Table 4). Reproducibility results showed high concordance correlation coefficients (ρ_c) for height and weight ($\rho_c = 0.933$ and 0.970, respectively) despite large limits of agreement (about ±6 cm and 8–10 kg, respectively), suggesting moderate agreement overall. Concordance correlation coefficients were substantially smaller for HbA1c ($\rho_c = 0.716$) and for blood pressure ($\rho_c = 0.5$–0.6), with large limits of agreement (±2% for HbA1c and ±25 mmHg for systolic blood pressure).

Stratified analyses did not show any statistically significant differences in reproducibility measures across strata. Nevertheless, we found that uniform kappa values were >10% better in women for HbA1c, lipid profile and weight controls, illustrating a tendency towards better agreement performance for women.

Discussion

The results of this study showed good agreement between patient and physician reports of blood pressure, HbA1c, weight and lipid profile measurements within the past 12 months. Agreement was, however, lower for reports of microalbuminuria, foot and eye examination. When comparing continuous outcomes from both sources, reliability (i.e. concordance correlation coefficients) was very good for height and weight, but moderate for HbA1c and blood pressure. Despite these high concordance correlation coefficients, limits of agreement remained large for all reported measurements, illustrating that agreement between patients and physicians was rather moderate.

Overall, reproducibility of diabetes-related process indicators was consistent with those of previous studies. Among the 8409 participants of the TRIAD study, Beckles *et al.* found only fair reliability

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Table 1 Patient and physician characteristics

Patients self-reported characteristics ($n = 210$)	
Age, years, mean (SD)	65.4 (10.5)
Women, no (%)	84 (40.0%)
Body Mass Index, mean (SD) ($n = 195$)	30.2 (6.1)
Education, no (%) ($n = 202$)	
Primary school	36 (17.8%)
Secondary school	124 (61.4%)
High school, university	42 (20.8%)
Civil status, no (%) ($n = 209$)	
Single	18 (8.6%)
Married	129 (61.7%)
Divorced, separated	37 (17.7%)
Widower	25 (12.0%)
Smoking status, no (%) ($n = 206$)	
Current	39 (18.9%)
Former	88 (42.7%)
Never	79 (38.3%)
Diabetes type, no (%)	
Type 1	29 (13.8%)
Type 2	140 (66.7%)
Other[a]	41 (19.5%)
Diabetes duration, no (%) ($n = 208$)[b]	
1–10 years	101 (48.6%)
11–20 years	67 (32.2%)
>20 years	40 (19.2%)
Diabetes treatment, no (%) ($n = 209$)[c]	
Oral hypoglycaemic drugs	107 (51.2%)
Insulin	46 (22.0%)
Oral hypoglycaemic drugs + insulin	56 (26.8%)
Diabetes complications, no (%) ($n = 202$)[d]	
Macrovascular complications	76 (37.6%)
Microvascular complications	52 (25.7%)
Subjective health, no (%) ($n = 205$)[e]	
Excellent	4 (2.0%)
Very good	31 (15.1%)
Good	128 (62.4%)
Fair	34 (16.6%)
Poor	8 (3.9%)
Physicians self-reported characteristics ($n = 110$)	
Age, years, mean (SD)	53.5 (8.8)
Women, no (%)	20 (18.2%)
Activity level $\geq$ 80% part time or full time, no (%) ($n = 106$)	76 (71.7%)
Specialty, no (%) ($n = 106$)[f]	
General or internal medicine board certified	79 (74.5%)
Endocrinology and diabetes board certified	17 (16.0%)
Other[g]	13 (12.3%)
Clinical practice location, no (%) ($n = 106$)	
Rural	21 (19.8%)
Urban	61 (57.5%)
Mixed	24 (22.6%)
Clinical setting, no (%) ($n = 107$)[f]	
Solo private practice	60 (56.1%)
Group private practice	40 (37.4%)
Ambulatory care centre	4 (3.7%)
Public hospital	8 (7.5%)

a: Other diabetes type (0.5%), did not know (12.4%), or no answer (6.7%).
b: Patients diagnosed diabetes less than one year before the survey were excluded.
c: Patients were eligible if they showed a prescription with oral hypoglycaemic drugs, insulin, glucose meter or strips.
d: Reported macrovascular diabetes complications were angina/myocardial infarction, stroke and peripheral neuropathy (foot pain/sensation loss, foot ulcers, amputation). Reported microvascular diabetes complications were retinopathy and nephropathy (dialysis or kidney transplant).
e: Subjective health was assessed by the first question of the 12-item Short Form Health Survey:[19] 'In general, would you say your health is excellent, very good, good, fair, or poor?'.
f: More than one answer possible.
g: Either non-board certified physicians, or other specialties.

Table 2 Process and outcomes of care as reported by patients and physicians

	Patients		Physicians	
Process of care results ($n = 210$)	*N*	%	*N*	%
HbA1c[a]	120	98%	207	97%
Lipid profile	203	97%	189	90%
Microalbuminuria	179	74%	132	75%
Foot examination	201	71%	144	92%
Eye examination[b]	201	60%	126	64%
Blood pressure	207	99%	208	99%
Weight	205	95%	191	95%
Influenza immunization	208	67%	86	93%
Mean outcomes of care ($n = 210$)	*N*	Mean	*N*	Mean
HbA1c, %[a]	78	7.4	118	7.4
Height, cm	195	171	174	170.2
Weight, kg	207	88.1	196	89.1
Systolic blood pressure, mmHg	108	133.5	209	133.9

a: Among those who knew what glycosylated haemoglobin (HbA1c) was.
b: By an ophthalmologist.

between self-reports and medical records (Cohen's kappa 0.25), with twice more self-reported annual examination than found in medical records.[10] Fowles *et al.* found high sensitivity in self-reported eye examination (89%) and HbA1c (99%), with low specificity (65% and 28%, resp.).[8] Comparing combined medical and administrative diabetes indicators with 440 patient self-reports, they also demonstrated more over-reporting than under-reporting by patients, and low Cohen's kappa values (0.371 and 0.678, resp.).[8] In another study, reports were higher than actual medical record data for annual eye examination, but not for annual foot examination and blood pressure.[7] Other studies described high sensitivity, low specificity and low Cohen's kappa of self-reported retinal examination compared with administrative data,[9] and low reproducibility between laboratory results.[20]

The concepts of reliability, agreement and reproducibility are often confused and used interchangeably, despite important conceptual differences.[21] In this study, we used reproducibility as an umbrella concept for reliability and agreement, referring to the reproducibility of a measurement in a test–retest situation, as suggested by de Vet *et al.*[21] While reliability relates to discrimination, i.e. how well can patients be classified into mutually exclusive categories (e.g., by two observers), agreement addresses measurement errors and assesses how close or similar repeated reports or measurements are.[22]

The concept of reproducibility, which comprises both reliability and agreement, has been the focus of the following two debated issues. First, the often reported paradoxical behaviour of Cohen's kappa (i.e. low values of Cohen kappa despite high raw agreement)[13,21,22], which completely disappears when Cohen's kappa is considered as a measure of reliability instead of a measure of agreement. In fact, uniform kappa exhibits a much more coherent and expected behaviour when used in place of Cohen's kappa as a measure of agreement. Second, the fact that limits of agreement may be large from a clinical perspective even with high concordance correlation coefficients (e.g. 0.95). Indeed, as the concordance correlation coefficient is sensitive to the range of measurements, only large concordance correlation coefficients (e.g. 0.999) correspond to narrow limits of agreement; it should therefore be interpreted as a reliability parameter rather than a measure of agreement, even if its name explicitly relates to concordance.

When assessing reproducibility, either high agreement or high reliability may be preferable, depending on the aim of the project. High reliability is preferred to discriminate subjects, because this does not preclude identifying patients with abnormal values even

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Table 3 Comparison of process indicators during the past 12 months, as reported by patients and physicians

	Reported by patient	Reported by physician			Agreement		Reliability	
		Not done	Done	*N*	Raw agreement	Uniform kappa (95% CI)[a]	Cohen's kappa (95% CI)	Bayesian kappa, median (95% CI)
Glycosylated haemoglobin (HbA1c)	Not done	0	2	117	0.97	0.93 (0.86, 0.98)	−0.02 (−0.05, 0.01)	0.15 (−0.02, 0.58)
	Done	2	113					
Lipid profile	Not done	0	5	182	0.89	0.78 (0.69, 0.86)	−0.04 (−0.08, −0.01)	0.01 (−0.05, 0.20)
	Done	15	162					
Microalbuminuria	Not done	7	10	112	0.69	0.39 (0.22, 0.56)	0.12 (−0.07, 0.31)	0.118 (−0.05, 0.31)
	Done	24	71					
Foot examination	Not done	0	29	136	0.72	0.44 (0.30, 0.59)	−0.11 (−0.18, −0.04)	−0.08 (−0.16, 0.04)
	Done	9	98					
Eye examination[b]	Not done	19	15	123	0.68	0.35 (0.18, 0.50)	0.26 (0.08, 0.43)	0.25 (0.08, 0.42)
	Done	25	64					
Blood pressure	Not done	0	3	205	0.97	0.941 (0.89, 0.98)	−0.02 (−0.04, −0.01)	0.12 (−0.01, 0.50)
	Done	3	199					
Weight	Not done	2	3	187	0.94	0.88 (0.81, 0.95)	0.24 (−0.06, 0.54)	0.24 (0.04, 0.53)
	Done	8	174					
Influenza immunization	Not done	0	8	86	0.84	0.67 (0.50, 0.83)	−0.09 (−0.16, −0.01)	−0.01 (−0.11, 0.25)
	Done	6	72					

a: Confidence intervals for uniform kappas were computed using the studentized bootstrap method.
b: By an ophthalmologist.

Table 4 Comparison of continuous clinical and laboratory results, as reported by patients and physicians

	N both reported by patient and physician	As reported by patient, mean (SD)	As reported by physician, mean (SD)	Concordance correlation coefficient (ρ_c)[17]	95% limits of agreement[18]
Glycosylated haemoglobin (HbA1c), %	82	7.33 (1.32)	7.42 (1.31)	0.716	(−2.03, 1.84)
Height, cm	160	170.7 (9.2)	170.4 (9.2)	0.933	(−6.3, 6.9)
Weight, kg	194	88.45 (19.78)	89.88 (20.90)	0.970	(−10.8, 8.0)
Systolic blood pressure, mmHg	108	133.5 (13.2)	133.7 (16.2)	0.627	(−25.3, 24.8)

when there are possibly large measurement errors and wide limits of agreement. To establish whether diagnoses, scores or judgments are identical, measurement error is of utmost importance and discrimination of subjects is no longer relevant. Good measures of agreement are therefore targeted.

In our study results, the apparent discrepancy between agreement and reliability measures may be explained by various reasons. First, the generally low reliability but good agreement of process indicators is an expected consequence of the usually large asymmetry of the marginal distributions of the observations in the cells of 2×2 tables, and this is known to greatly influence Cohen's kappa.[13,21] For some indicators (e.g. HbA1c or blood pressure), agreement was substantial, suggesting that patient report may be quite accurate. Second, the high reliability of some outcome results demonstrates that patient and physician reports matched well when it came to magnitude and that these results were good enough for identifying subgroups of patients with abnormal values. However, under the magnifying lens of the limits of agreement, reports were inaccurate and discrepant, and limits of agreement too large to be useful for any clinical decision regarding treatment or patient monitoring. This was typically the case of height and weight reports.

We found good agreement for tests routinely done and easy to understand by patients, such as blood pressure, HbA1c, weight and lipid profile. This contrasted with the low agreement found for microalbuminuria, foot and eye examination. It may be explained by patient and physician factors. Indeed, patient self-report has been shown to be subject to recall bias (patients may forget if they had a specific test), telescoping (remembering an event as more recent than it actually was, e.g. a retinal examination performed in the past 2 years instead of 1 year)[9] and social acceptance bias (expectation of a more desirable answer).[8] Moreover, patients with diabetes may lack specific information or knowledge to recognize which test was performed. This may be especially true for those tests presenting lower agreement values, as several aspects can be assessed while analysing urine, or examining the eyes and feet, without having physicians telling all details to patients. Possible physician factors are that reports in medical records might be subject to bias, such as under-reporting. This was shown in a study comparing process-based scores using standardized patients, clinical vignettes and medical charts that showed that medical chart's scores were 5% lower than those using clinical vignettes, and 10% lower than those using standardized patients.[23] Another explanation includes fragmentation of care and the communication gap between health care providers that might lead to poor reproducibility of reports when contacting only one physician per patient.

As opposed to several published studies, we made a clear distinction between agreement and reliability parameters and used appropriate measures of agreement. Moreover, we considered several process and outcome of care indicators. Nevertheless, our study bears some limitations. First, our sample might be different from the general population of patients with diabetes because we targeted only those who visited pharmacies with a diabetes-related prescription and disease duration of at least 12 months. Also, patients not fluent enough in French to fill in a questionnaire were excluded from the study. However, the proportion of adults with known and untreated diabetes should nevertheless remain small, as current guidelines recommend early drug treatment; in addition, characteristics of included patients did not differ much from those of other similar studies.[8,24] Also, participating physicians may present different characteristics from Swiss physicians. Compared with

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Swiss physicians active in ambulatory care settings in 2011, participating physicians' characteristics were similar except for a lower proportion of female physicians in our sample (33% vs. 18%, respectively).[25] Second, data from both patients and physicians were not available for all possible pairs of respondents. In fact, data were mainly missing when physicians did not report some information or did not send back the report cards (Table 2); whether non-response to a question represents absence of performance is only speculative. Also, physicians whose contact details were given by patients may not have been the ones who performed the last clinical or laboratory test or described process of care. Therefore, patients and physicians may not always have referred to the same clinical encounter even if the word 'last' was specified; some may have been tempted to game the survey. However, because both patients and physicians reported data independently, all these limitations should result in non-differential misclassification and, at worst, to lower reliability and agreement results. In addition, characteristics of patients with and without physicians' data were similar in terms of age, gender, type, duration and treatment of diabetes, BMI, smoking status, civil status, education and self-reported health. Third, we considered a 12-month cut-off for process indicators, while some guidelines recommend more than one test a year (such as for HbA1c, blood pressure or lipid profile).[6] However, this cut-off was chosen because it is commonly used and would help in comparing results across studies.

Our findings may raise health care professionals' awareness of which self-reported measurements they may rely on. Indeed, they may rely with confidence on information relating to processes of care [for example whether a previous HbA1c, blood pressure or lipid profile was performed in another clinical setting (good agreement)], but not on their absolute values, as the latter showed lower reliability (i.e. concordance correlation coefficients) in our study.

In conclusion, quality of care evaluation should be made with caution when using self-report measures. For some processes of care, relying solely on patient self-reported values may be unsuitable for monitoring and decision making. Indeed, while they may be appropriately used when patients are the only source of information (particularly for simple and understandable processes of care), it may be less appropriate when the reports concern processes of care whose purpose patients have more difficulties understanding. Further efforts should target improvement of survey methods (designing and clarifying self-reported questions for example), development of communication skills to help health care providers better communicate with each other and their patients and better access to diabetes education services as well as broader adoption of the use of electronic medical records.

Acknowledgements

We would like to thank all pharmacies, physicians and patients who participated in the study. We also thank Mrs A. Casillas (Institute of Social and Preventive Medicine, Lausanne University Hospital, Switzerland) for copy-editing a previous version of the manuscript. None of the authors has any conflict of interest to declare.

T.H.C. and I.P.B. interpreted the results and wrote the manuscript. P.T. performed statistical analyses, interpreted the results, participated to the writing of the manuscript and provided insightful comments for the discussion. J.B. and I.P.B. designed the survey and collected the data. B.B. contributed to the interpretation of the results and reviewed the manuscript. I.P.B. is the principal investigator of the study and the guarantor of the content of the article.

An oral presentation of the study was given at the Swiss Society of General Internal Medicine Annual Meeting 2013 in Basel, Switzerland, under the title 'Comparison of diabetes quality of care indicators as reported by patients and primary care physicians'.

Funding

This work was supported by the Department of Public Health of the canton of Vaud, Switzerland ('Programme cantonal Diabète'), and by the Swiss National Science Foundation. Dr. T-H Collet's research is supported by a grant from the Swiss National Science Foundation (PBLAP3-145870). Dr. I. Peytremann-Bridevaux is supported by a grant from the Swiss National Science Foundation [PROSPER N° 32333B-123817 and N° 32333B-139789].

Conflicts of interest: None declared.

Key points

- Patient and physician agreement was good for routine processes of care within the past 12 months such as blood pressure, HbA1c, weight and lipid profile measurements, and less so for microalbuminuria, foot and eye examinations.
- Reproducibility, agreement and reliability are terms often confused and used interchangeably, despite conceptual differences. We used reproducibility as an umbrella concept for reliability (the ability to discriminate and classify individuals into mutually exclusive categories, for example by two observers) and agreement (the assessment of how close or similar repeated reports or measurements are).
- Quality of care evaluation should be made with caution when using self-report measures only, especially for processes of care whose purpose patients have more difficulties understanding.

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European Journal of Public Health, Vol. 24, No. 6, 1009–1016
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doi:10.1093/eurpub/cku013 Advance Access published on 5 March 2014

Impact of physicians' attitude to vaccination on local vaccination coverage for pertussis and measles in Germany

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Background: Vaccination rates of children in Germany are unsatisfying and regional endemic outbreaks have been reported. Few studies have analysed physicians' attitude towards vaccination. We investigated whether there is an association between physicians' attitude and vaccination coverage on the regional level for Germany. **Methods:** In a representative cross-sectional survey, anonymized questionnaires were sent to random samples of all paediatricians (50%) and general practitioners (10%) in private practice in Germany. Attitude towards vaccination was operationalized in three scores. Measles and pertussis vaccination coverage rates were obtained from the 16 Federal States' Health Departments. Geographic methods and linear regression models were used for analysis. **Results:** A total of 2010 paediatricians (response proportion: 64.1%) and 1712 general practitioners (response proportion 39.1%) were included in the analysis. We found an association of physicians' attitude towards vaccination and vaccination coverage rate ($P < 0.0001$). There is also an important association between vaccination coverage and the geographic location, with lower coverage rates especially in the States of former Western Germany (compared with our reference State Mecklenburg - Western Pomerania; pertussis: maximum −5.86% in Bavaria, $P < 0.0001$; measles: maximum −20.20% in Berlin, $P = 0.0002$). **Conclusions:** The regional association between vaccination coverage rates and physicians' attitude towards vaccination seems to be superposed by population-related variables. An increase of vaccination coverage requires better information and training of both, physicians and the general population.

Introduction

Vaccinations are an effective way to prevent childhood infectious diseases which may cause severe complications including lasting retardation and death. For some preventable diseases, the vaccination rate should warrant a population wide protection by the herd effect, i.e. the pathogen should become unable to spread due to a too low proportion of susceptible individuals remaining.

In Germany, vaccination rates have been declining. In some areas, vaccination rates are already insufficient[1] and endemic onsets of

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