

Understanding Patients' Adherence-Related Beliefs about Medicines Prescribed for Long-Term Conditions: A Meta-Analytic Review of the Necessity-Concerns Framework

Rob Horne^{1*}, Sarah C. E. Chapman¹, Rhian Parham¹, Nick Freemantle², Alastair Forbes³, Vanessa Cooper^{1‡}

1 Centre for Behavioural Medicine, Department of Practice and Policy, UCL School of Pharmacy, London, United Kingdom, **2** Department of Primary Care and Population Health, University College London, London, United Kingdom, **3** Department of Internal Medicine, University College Hospital, London, United Kingdom

Abstract

Background: Patients' beliefs about treatment influence treatment engagement and adherence. The Necessity-Concerns Framework postulates that adherence is influenced by implicit judgements of personal need for the treatment (necessity beliefs) and concerns about the potential adverse consequences of taking it.

Objective: To assess the utility of the NCF in explaining nonadherence to prescribed medicines.

Data sources: We searched EMBASE, Medline, PsycInfo, CDSR/DARE/CCT and CINAHL from January 1999 to April 2013 and handsearched reference sections from relevant articles.

Study eligibility criteria: Studies using the Beliefs about Medicines Questionnaire (BMQ) to examine perceptions of personal necessity for medication and concerns about potential adverse effects, in relation to a measure of adherence to medication.

Participants: Patients with long-term conditions.

Study appraisal and synthesis methods: Systematic review and meta-analysis of methodological quality was assessed by two independent reviewers. We pooled odds ratios for adherence using random effects models.

Results: We identified 3777 studies, of which 94 (N = 25,072) fulfilled the inclusion criteria. Across studies, higher adherence was associated with stronger perceptions of necessity of treatment, OR = 1.742, 95% CI [1.569, 1.934], $p < 0.0001$, and fewer Concerns about treatment, OR = 0.504, 95% CI: [0.450, 0.564], $p < 0.0001$. These relationships remained significant when data were stratified by study size, the country in which the research was conducted and the type of adherence measure used.

Limitations: Few prospective longitudinal studies using objective adherence measures were identified.

Conclusions: The Necessity-Concerns Framework is a useful conceptual model for understanding patients' perspectives on prescribed medicines. Taking account of patients' necessity beliefs and concerns could enhance the quality of prescribing by helping clinicians to engage patients in treatment decisions and support optimal adherence to appropriate prescriptions.

Citation: Horne R, Chapman SCE, Parham R, Freemantle N, Forbes A, et al. (2013) Understanding Patients' Adherence-Related Beliefs about Medicines Prescribed for Long-Term Conditions: A Meta-Analytic Review of the Necessity-Concerns Framework. PLoS ONE 8(12): e80633. doi:10.1371/journal.pone.0080633

Editor: Yinglin Xia, University of Rochester, United States of America

Received: March 5, 2013; **Accepted:** October 4, 2013; **Published:** December 2, 2013

Copyright: © 2013 Horne et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: These authors have no support or funding to report.

Competing Interests: The authors have performed consultancy for Nycomed, Takeda, B Braun, Shire, Warner Chilcott, Abbott, MSD, and the university spin out consultancy company, Spoonful of Sugar of which RH is a shareholder; RH has undertaken speaker engagements with honoraria for pharmaceutical companies, RH has received consultancy payments from pharmaceutical companies related to the use of the BMQ in industry sponsored studies. There are no other relationships or activities that could appear to have influenced the submitted work. This does not alter the authors' adherence to all the PLOS ONE policies on sharing data and materials.

* E-mail: r.horne@ucl.ac.uk

‡ Current address: Elton John Centre, Brighton and Sussex University Hospitals NHS Trust, Brighton, United Kingdom

Introduction

Prescribing medicines is fundamental to the medical management of most long-term conditions. However, approximately half

of this medication is not taken as directed, representing a failure to translate potentially effective treatment into optimal outcomes for patients and society [1,2]. Where prescriptions are appropriate, this level of nonadherence has potentially serious consequences,

both for individual patients, in terms of lost opportunities for health gain with increased morbidity and mortality [3], and for the health care system, in terms of wasted resources, increased use of services and hospital admissions [4].

In the absence of a single definitive intervention to address nonadherence [5], the NICE Medicines Adherence Guidelines amalgamate insights from trials of interventions and explanatory studies of nonadherence [1]. They apply a perceptions and practicalities approach [4] recognising that nonadherence may be both unintentional and intentional. Unintentional nonadherence occurs when the patient wants to adhere but is unable to because they lack capacity or resources. For example, they may not have understood the instructions, cannot afford copayment costs, or find it difficult to schedule, administer or remember the treatment. Intentional nonadherence occurs when the patient decides not to follow the recommendations. It is best understood in terms of the perceptual factors (e.g. beliefs and preferences) influencing motivation to start and continue with treatment.

Prescribing consultations do not occur in a vacuum. Patients (and prescribers) bring pre-existing beliefs about the illness and treatment [6,7] which influence the patient's evaluation of the prescription, their adherence and even beneficial [8] or adverse outcomes [9]. Interventions to optimise adherence tend to be more effective if they are tailored to the needs of the individual taking account of the perceptions of the treatment as well as practical abilities and resources that enable or impede their adherence [10]. Although the perceptual and practical dimensions of adherence are influenced by the social, cultural, economic and healthcare system contexts, taking account of the patient's beliefs about the prescribed medication is fundamental to shared-decision making and supporting adherence [1,11].

Research conducted with patients with a variety of long-term conditions suggests that the key beliefs influencing patients' common-sense evaluations of prescribed medicines can be grouped under two categories: perceptions of personal need for treatment (Necessity beliefs) and Concerns about a range of potential adverse consequences [7,12,13]. This 'Necessity-Concerns Framework (NCF)' potentially offers a convenient model for clinicians to elicit and address key beliefs underpinning patients' attitudes and decisions about treatment.

Over the past decade, a number of studies have been conducted, using a validated questionnaire, the Beliefs about Medicines Questionnaire [14] to quantify Necessity beliefs and Concerns in order to explore the relationship between these beliefs and adherence. This research spans a range of long-term medical conditions, across different settings and within various cultural groups. Many of the individual studies have demonstrated the utility of the NCF in explaining nonadherence to medication (e.g. [15–18]). It is therefore timely that a meta-analysis is performed to consolidate the results from these studies and to examine the explanatory value of the NCF in predicting adherence to medication prescribed for long-term medical conditions. In line with the underlying theory, we hypothesized that adherence in long-term conditions would be associated with stronger perceptions of Necessity for treatment and fewer Concerns about adverse consequences.

Methods

This review was conducted in line with the MOOSE guidelines for meta-analysis of observational trials [19].

Literature Search

A computerised literature search was conducted by the investigators on April 22nd, 2013 using EMBASE, Medline,

PsycInfo, CDSR/DARE/CCT and CINAHL. The search strategy included the following terms:

BMQ or beliefs

and

treatment\$ **or** medicine\$ **or** medication\$

and

adheren\$ **or** complian\$

The search was limited to studies published from the year 1999 onwards (the year in which the BMQ was published). Duplicates were removed.

Inclusion and Exclusion Criteria

Identified studies were included in the meta-analysis if they met the following criteria:

- (1) participants were suffering from a long-term condition
- (2) participants were taking medication
- (3) participants were adults
- (4) the article was published in a peer-reviewed journal
- (5) the Necessity and/or Concerns subscales of the BMQ were used
- (6) a measure of adherence was employed

There were no restrictions based on language, or on cultural or geographical factors.

Titles and abstracts were screened for relevance, and the full text of relevant articles was obtained. Data from each article was extracted as described below.

Selection of Results When Multiple Relationships between Beliefs and Adherence Were Reported

Fifteen studies reported multiple associations of beliefs related to different adherence measurements (details reported in Table 1). Where the choice was between adherence measures, the most objective measure was selected for the meta-analysis. Therefore, electronic monitoring of adherence [20] and prescription redemption data [16] were chosen over self-report. Where data was presented for both 'on demand' and prophylactic medications, data for the prophylactic medication data were chosen [21,22], for consistency with medications prescribed for other long-term conditions. In studies where cross-sectional and longitudinal data were both available, longitudinal data was used within the analysis [21,23–26]. Where one group provided cross-sectional data at multiple timepoints, the timepoint with the fewest missing data points was selected [27]. If the choice was between two self report measures of adherence, we used the more commonly used measure. Thus the Morisky Medication Adherence Scale (MMAS) was chosen over the Brief Medication Questionnaire [28] and the ACTG adherence measure was used over the Walsh VAS scale [29]. Where patients within a sample were taking multiple medications and individual associations were provided for each medication [30,31], the mean association was used within the meta-analysis but individual effect sizes are reported in Table 1 to facilitate comparison. Where data on two samples are reported within the same study [32,33] we included both associations within the analysis.

Data Extraction

The following information was extracted from papers onto coding forms: author names, date of publication, the country in which the research was conducted (dichotomized into UK or non-UK), sample size, illness group, sex (% male), mean age, study design (cross-sectional, longitudinal or prospective), the number of

Table 1. Summary Data for Included Studies.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
Aakre et al. (2012) [171]	USA	Comorbid Serious Mental Illness and Type II Diabetes	44	45%	51.1 (9.3)	Cross-sectional	1) Brief Medication Questionnaire (Antipsychotic medication) 2) Brief Medication Questionnaire (Hypoglycaemic medication)	Necessity (5) Concerns (6) Necessity (5) Concerns (6)	1.467 0.977 4.151 0.673	0.523 0.969 0.024 0.520
Aflakseir (2012) [172]	IRN	Type II Diabetes	102	22%	40.7 (11.4)	Cross-sectional	MARS 10 item version see Barnes et al., 2004	Necessity (5) Concerns (5)	1.670 0.169	0.172 <0.001
Aikens et al. (2005) [28]	USA	Depression	82	21%	42.9 (10.63)	Cross-sectional	1) General adherence: 4-item MMAS ^a 2) Recent adherence: 3-item Brief Medication Questionnaire	Necessity (5) Concerns (5) Necessity (5) Concerns (5)	2.097 0.247 3.129 0.333	0.075 0.001 0.008 0.009
Aikens & Plette (2009) [173]	USA	Diabetes	803	38%	55.3 (11.8)	Cross-sectional	Single item	Necessity (5) Concerns (6)	1.430 0.357	0.069 <0.001
Aikens & Klinkman (2012) [174]	USA	Depression	163	38%	35 (10)	Prospective	Brief Medication Questionnaire AND STAR*D Medication Adherence Questionnaire	Necessity (5) Concerns (5)	2.582 0.683	0.002 0.195
Allen LaPointe et al. (2011) [31]	USA	Acute Coronary Syndrome	972	6 groups in range 66–74%	Medians for 6 groups between 56–61 SD not reported	Prospective	Self-report of no discontinuation nor missed doses in last month for 1) ACEI/ARB; 2) Beta-blocker and 3) Lipid-lowering therapy	Necessity (5) Concerns (5) Necessity (5) Concerns (5)	1.262 0.549 1.315 0.546	0.137 <0.001 0.059 <0.001
Barnes et al. (2004) [175]	NZ	Diabetes	82	Not reported	European 59.6 (12.7); Tongan 59.2 (11.2)	Cross-sectional	MARS plus two items re natural remedies	Necessity (5) Concerns (5)	4.054 1.670	0.001 0.213
Batchelder et al. (2013) [30]	USA	Comorbid HIV and Type II Diabetes	62	45%	52.8 (7.3)	Cross-sectional	5-item MARS 1) Antiretroviral 2) Diabetes medication	Necessity Concerns Necessity Concerns Unspecified	1.300 0.200 1.050 0.450	0.306 0.001 0.878 0.041
Beck et al.	SWZ	Schizophrenia	150	65.3%	44.9 (11.7)	Cross-sectional	Medication adherence	Necessity (5)	1.942	0.029

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
(2011) [176]		or Schizoaffective Disorder				sectional	subscale of the Service Engagement Scale (Tait et al., 2002)- clinician rated. Brief Adherence Rating Scale (BARS; Byerly et al., 2008) BARS selected for use here	Concerns (5)	0.775	0.396
Berglund et al. (2013) [177]	SWE	Statins Users	414	50.8%	64.2 (9.5)	Cross-sectional	4-item MMAS	Necessity (5)	2.266	<0.001
Bhattacharya et al. (2012) [178]	UK	Colorectal or Breast Cancer	43	44.2%	64.5 (7.4)	Cross-sectional	5-item MARS	Concerns (5)	1.338	0.105
Brown et al. (2005) [179]	USA	Depression	192	29%	45.2 (16.0)	Cross-sectional	4-item MMAS	Necessity (5)	1.408	0.562
						sectional (Longitudinal study but only baseline results reported)		Concerns (5)	0.570	0.352
								Necessity (5)	1.235	0.425
								Concerns (5)	0.362	<0.001
Brown et al. (2013) [160]	USA	HIV	116	58%	45.3 (8.6)	Cross-sectional	VAS scale 0-100% used to rate adherence to each medication over the last month dichotomized at 95%	Necessity (8)	2.357	0.014
Butler et al. (2004) [180]	UK	Renal Transplant	58	66%	48.0 (13)	Cross-sectional	Electronic monitors ^b	Necessity (5)	4.871	0.003
Byer & Myers (2000) [16]	UK	Asthma	64	50%	39.6 (13.83)	Cross-sectional	1) Number of preventer inhaler prescriptions collected ^a	Concerns (7)	0.517	0.184
							2) Number of reliever inhaler prescriptions collected	Necessity (5)	5.915	0.001
							3) Self-reported adherence	Concerns (5)	-	-
								Necessity (5)	3.129	0.05
								Concerns (5)	-	-
								Necessity (5)	5.915	0.001
								Concerns (5)	-	-
Byrne et al. (2005) [17]	IRE	Coronary Heart Disease	1084	65%	66.0 (9.1)	Cross-sectional	5-item MARS	Necessity (5)	2.551	<0.001
Chisholm-Burns et al. (2012) [181]	USA	Renal Transplant	512	61.1%	52.4 (10.7)	Cross-sectional	Immunosuppressant Therapy Adherence Scale (ITAS) <12 non-adherence	Concerns (5)	0.669	<0.001
Clatworthy et al. (2009) [18]	UK	Bipolar Disorders	223	36%	48 (11.2)	Cross-sectional	5-item MARS	Necessity (5)	2.065	<0.001
Clifford et al.	UK	Chronic illness	146	52%	64.3 (12.06)	Longitudinal	Telephone call ("When	Concerns (6)	0.371	0.001
								Necessity (5)	1.764	0.090

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
(2008) [142]							was the last time you missed a dose of this medicine?'). Nonadherence defined as any dose missed in the previous 7 days ^b	Concerns (5)	0.457	0.020
Cooper et al., (2011) [182]	UK	HIV	234	84%	42 (8.9)	Longitudinal	At 48 weeks MARS I (Walsh et al., 2002) scale-VAS % taken over last month dichotomized at 95%	Necessity (15)	1.863	0.010
de Boer-van der Kolk et al. (2008) [183]	NL	HIV	341	90%	45	Cross-sectional	Self report % of prescribed medicines taken	Necessity (8)	1.600	0.018
De Las Cuevas et al. (2013) [184]	ESP	Affective Disorders	167	23.4%	56.1 (12.3)	Cross-sectional	4-item MMAS	Concerns (11)	0.070	0.075
De Smedt et al. (2012) [185]	NL	Heart Failure	960	63.6%	69.6 (11.9)	Cross-sectional	SECOPE non-adherence subscale (Johnson & Neilands, 2007)	Concerns (5)	1.111	0.710
de Thurah et al. (2010) [21]	DMK	Rheumatoid Arthritis	91	36%	Median 63	Prospective	CQ-R 1) 9 months 2) baseline	Concerns (5)	0.484	0.112
Ediger et al. (2007) [186]	CAN	IBD	326	40%	41.0 (14.06)	Cross-sectional	5-item MARS ^b	Necessity (5)	9.600	<0.001
Emilsson et al. (2011) [187]	SWE	Asthma	35	28.6%	52.9 (14.7)	Cross-sectional	Pill count	Concerns (5)	0.420	0.132
Fawzi et al. (2012) [188]	EGT	Depression or Adjustment Disorder with Depressed Mood	108	33.3%	61.3 (5.3)	Cross-sectional	10-item MARS	Necessity (5)	3.630	0.016
Foo et al. (2012) [189]	SGP	Glaucoma	344	64.8%	66.1 (10.2)	Cross-sectional	8-item MMAS dichot. at 8	Concerns (5)	0.793	0.652
French et al. (2013) [23]	UK	Type II Diabetes	453	57.4%	65.9 (10)	Prospective	(Thompson et al., 2000) MARS chosen and GAM (global adherence measure- 1 item)	Necessity (5)	1.522	0.039
Gauchet et al. (2007) [190]	FRA	HIV	127	78%	39.7 (9.2)	Cross-sectional	8-item MARS dichot. at 2) Prospective	Concerns (5)	0.677	0.054
Gatti et al.	USA	Chronic illness	275	27%	-	Cross-sectional	16-item self-report measure (devised by authors)	Concerns (5)	4.438	0.032
							8-item MMAS dichot. at	Concerns (5)	0.555	0.365
								Necessity (5)	3.712	0.001
								Concerns (5)	0.269	0.001
								Necessity (4)	1.045	0.837
								Concerns (5)	2.778	<0.001
								Necessity (5)	1.295	0.232
								Concerns (5)	0.525	0.004
								Necessity (5)	1.800	0.013
								Concerns (5)	0.116	<0.001
								Necessity (5)	3.264	0.001
								Concerns (5)	0.865	0.656
								Necessity (5)	1.239	0.331

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
(2009) [191]						sectional	1	Concerns (6)	0.357	<0.001
George & Shalansky (2007) [192]	CAN	Heart Failure	350	69%	61.0 (12.6)	Cross-sectional	1) Prescription dispensing data (nonadherence defined as <90% mean refill adherence) ^b 2) 4-item MMAS ^c	Necessity (5) Concerns (5)	1.529 0.954	0.069 0.839
Gonzalez et al. (2007) [20]	USA	HIV	325	60%	40.9 (8.5)	Longitudinal randomised trial	1) ACTG 2) MEMS cap – one drug in each participant's regimen monitored, usually the protease inhibitor (% adherence) ^a	Necessity (8) Concerns (11) Necessity (8) Concerns (11)	1.494 0.459 1.494 0.720	0.048 <0.001 0.048 0.106
Griva et al. (2012) [193]	UK	Kidney Transplant	218	59.6%	49.7 (12.3)	Cross-sectional	5-item MARS item plus serum immunosuppressant concentrations	Necessity (5) Concerns (5)	7.278	<0.001
Grunfeld et al. (2005) [194]	UK	Breast Cancer	110	0%	56.3 (7.0)	Cross-sectional	1) Asked "in the past ^c week have you taken your tamoxifen everyday?" (Yes/No) ^b 2) 5-item MARS	Necessity (5) Concerns (5)	2.916 0.868	0.007 0.708
Hedenrud et al. (2008) [195]	SWE	Migraine	174	16%	Not calculable	Cross-sectional	5-item MARS ^b	Necessity (5) Concerns (5)	0.747 0.588	0.309 0.064
Horne et al. (1999) [14]	UK	Cardiac and General Medical (pooled data)	210	49%	50.8 (16.2)	Cross-sectional	4-item RAM	Necessity (5) Concerns (5)	2.018 0.347	0.006 <0.001
Horne & Weinman (1999) [7]	UK	Asthma, Renal Cardiac, Oncology (pooled data)	324	54%	54.1 (15.96)	Cross-sectional	4-item MARS	Necessity (5) Concerns (5)	2.180 0.281	<0.001 <0.001
Horne et al. (2001) [196]	UK	Renal (Haemodialysis)	47	49%	49.0 (17.3)	Cross-sectional	Single item: 'How often do you deliberately miss a dose of medication?'	Necessity (5) Concerns (5)	1.115 0.215	0.842 0.010
Horne & Weinman (2002) [166]	UK	Asthma	100	39%	49.3 (18.1)	Cross-sectional	9-item MARS	Necessity (6) Concerns (11)	3.405 0.178	0.002 <0.001
Horne et al. (2004) [197]	UK	HIV	109	97%	41.2 (9.0)	Cross-sectional	Single item: 'How much of your HAART medication did you take within two hours of when you were supposed to?'	Necessity (8) Concerns (11)	1.773 0.524	0.126 0.095
Horne et al.	UK	HIV	117	96%	37.8 (8.4)	Prospective	Single item: VAS from	Necessity (6)	2.477	0.008

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
(2007) [198]						follow-up	MASRI ^b	Concerns (7)	0.298	<0.001
Horne et al. (2009) [167]	UK	IBD	1871	37%	50 (16.0)	Cross-sectional	4-item MARS	Necessity (8)	1.790	<0.001
Horne et al. (2010) [24]	UK	Hypertension	230	88%	67.6	Prospective	1) 6-item MARS–baseline 2) 6-item MARS	Concerns (9) Necessity (5) Concerns (6) Necessity (5)	0.600 1.675 0.464 1.007	<0.001 0.096 0.013 0.987
Hou et al. (2010) [199]	UK	Bipolar	35	28.6%	45 (11)	Cross-sectional	MMAS 4-item (dichot. at 1)	Necessity (5) Concerns (5)	0.881 0.680	0.837 0.532
Hunot et al. (2007) [200]	UK	Affective Disorder Depression	178	25%	40.1 (12.6)	Longitudinal	1) Single item: current antidepressant use/non-use ("Are you currently taking antidepressants?") ^a 2) MARS ^c 3) Prescription refill data ^c	Necessity (5) Concerns (6)	3.346 0.223	<0.001 <0.001
Iihara et al. (2010) [201]	JPN	Hospital Inpatients	151	62.3%	–	Cross-sectional	Measure based on MMAS	Necessity (5) Concerns (5)	1.998 0.593	0.020 0.079
Johnson et al. (2012) [29]	USA	HIV	295	100%	45.2 (10.1)	Cross-sectional	1) ACTG 3 days % taken dichot. at 100% ^a 2) Walsh VAS 0–100% last 30 days dichot at 100%	Necessity (5) Concerns (5)	0.960 0.930	0.365 0.058
Jonsdottir et al. (2009) [202]	UK	Schizophrenia/ Bipolar disorder	280	51%	35.1	Cross-sectional	VAS (0%–100%)	Necessity (8) Concerns (9)	0.960 5.887	0.273 <0.001
Kemp et al. (2007) [203]	UK	Epilepsy	37	51%	40.7 (SD not reported)	Cross-sectional	Low-dose of phenobarbital indicative of nonadherence, and/or measurement of antiepileptic drug levels	Necessity (5) Concerns (5)	0.441 0.599	0.200 0.414
Khandaria et al. (2008) [204]	USA	Coronary Artery Bypass Graft	132	83%	65.8 (10.1)	Cross-sectional	4-item MMAS ^b	Necessity (5) Concerns (5)	1.050 0.584	0.875 0.092
Kressin et al. (2010) [205]	USA	Hypertension	806	35%	59	Cross-sectional	Hill-Bone Compliance to High Blood Pressure Therapy Scale, 9 item adherence subscale	Necessity (5) Concerns (5)	1.414 0.525	0.200 <0.001
Kronish et al.	USA	Stroke or TIA	600	60.6%	63.4 (11.2)	Cross-sectional	8-item MMAS dichot. at	Necessity (5)	1.120	0.557

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
(2013) [206]						sectional	>=6	Concerns (4) (modified 0.193 items)		<0.001
Kung et al. (2012) [207]	NZ	Heart, Liver, Lung Transplant	326	64.4%	Heart transplant: 54.4 (11.8) Lung transplant 49.3 (13.1) Liver transplant 55.1 (12.3)	Cross-sectional	Immunosuppressant	Necessity (5)	1.605	0.021
Llewellyn et al. (2003) [22]	UK	Haemophilia	65	100%	36.4 (12.2)	Cross-sectional	1) Adherence to frequency of prophylactic infusion with clotting factor ^a 2) Adherence to recommended 'on demand' dose of clotting factor 3) Adherence to recommended dose of clotting factor ^c	Necessity (5) Concerns (5) Necessity (5) Concerns (5)	5.915 0.599 4.241 0.897	0.001 0.270 0.004 0.813
Maguire et al. (2008) [208]	UK	Hypertension	327	46%	Not reported	Cross-sectional	4-item RAM	Necessity (5)	0.665	0.242
Mahler et al. (2012) [209]	GMY	Mixed Chronic Illness	360	53.3%	69.5 range 19–95	Cross-sectional	5-item MARS D	Concerns (5) Necessity (5)	0.422 2.097	0.014 <0.001
Maidment et al. (2002) [15]	UK	Depression (older adults)	67	49%	74.2 (6.1)	Cross-sectional	Global Adherence Measure (single rating by interviewer)	Concerns (5) Necessity (5)	0.515 3.002	0.001 0.020
Menckebert et al. (2008) [210]	NL	Asthma	238	33%	36.2 (6.3)	Cross-sectional	5-item MARS	Necessity (9)	3.878	<0.001
Moshkowska et al. (2009) [211]	UK	Ulcerative Colitis	169	51%	49 (SD not reported)	Cross-sectional	1) 12 item study specific self report questionnaire	Concerns (12) Necessity (5)	0.496 1.976	0.004 0.002
Nakhtina et al. (2011) [212]	USA	Epilepsy	72	37.5%	44 (14.2)	Cross-sectional	4-item MMAS	Concerns (6) Necessity (5)	0.639 1.388	0.035 0.455
Neame & Hammond (2005) [213]	UK	Rheumatoid Arthritis	344	33%	49.5% aged over 65	Cross-sectional	Single item: 'I often do not take my medicines as directed' ^b	Concerns (5)	0.694	0.406
Nicklas et al. (2010) [214]	UK	Chronic Pain	217	–	–	Cross-sectional	6-item MARS	Necessity (5)	0.885	0.737
O'Carroll et al. (2006) [215]	UK	Liver Transplant	33	52%	55.8 (13.37)	Cross-sectional	1) 'Medication adherence' factor of the Transplant Effects Questionnaire (TXEQ) 2) 5-item MARS ^c	Concerns (5) Necessity (5) Concerns (5)	0.313 2.018 0.645	0.002 0.005 0.079
									1.734	0.411
									0.137	0.009

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
O'Carroll et al. (2011) [25]	UK	Ischaemic Stroke	180	54%	69 (11.4)	Cross-sectional	5-item MARS with salicylic acid/creatinine	Necessity (5) Concerns (5)	0.705 0.209	0.202 <0.001
Ovchinnikova et al. (2011) [26]	AUS	Asthma	134	31%	53 (19)	Longitudinal	1) Baseline 2) Prospective MARS 1) Baseline 2)	Necessity (5) Concerns (5) Necessity (5) Concerns (5)	0.778 0.328 1.429	0.359 <0.001 0.262
Percival et al. (2012) [216]	AUS	Heart Failure	43	83.7%	64.2 (17.1)	Cross-sectional	5-item MARS dichot. at 23	Necessity (5) Concerns (5)	0.278 3.068	<0.001 0.165
Peters et al. (2001) [217]	USA	Marfan Syndrome	174	42%	39.8 (12.2)	Cross-sectional	3-item self-report measure (adapted from MARS)	Necessity (5) Concerns (5)	1.299 0.424	0.417 0.010
Phatak & Thomas (2006) [218]	USA	Hypertension, Arthritis, Back Problems, Asthma, Hypercholesterolemia	250	38%	<30 (11.2%) 30–39 (1.4%) 40–49 (37.2%) 50–59 (24.4%) >60 (13.2%)	Cross-sectional	9-item MMAS	Necessity (5) Concerns (6)	1.550 0.215	0.059 <0.001
Rajpura & Nayak (2013)	USA	Hypertension and aged 55 or over	117	64.1%	55–65 (23.9%) >65 (52.1%)	Cross-sectional	MMAS	Necessity (5) Concerns (5)	2.551 0.423	0.008 0.014
Rees et al. (2010) [219]	AUS	Glaucoma	131	61.1%	67.7 (13.6)	Cross-sectional	4-item RAM	Necessity (5) Concerns (8)	1.966 0.651	0.035 0.180
Rees et al. (2013) [220]	USA, SGP, AUS	Glaucoma	475	55.4%	African Americans: 69.6 (12.4) White Americans: 68.65 (13.0) Australians: 69.2 (13.1) Singaporeans: 65.1 (11.8)	Cross-sectional	4-item RAM	Necessity (5) Concerns (8)	2.385 0.414	<0.001 <0.001
Reynolds et al. (2012) [221]	USA	Osteoporosis	193	0%		Cross-sectional	Osteoporosis Specific 8-item MMAS	Necessity (5) Concerns (6)	3.405 0.424	<0.001 0.005
Ross et al. (2004) [159]	UK	Hypertension	515	52%	59.9 (12.16)	Cross-sectional	4-item MMAS ^b	Necessity (5) Concerns (5)	3.060	0.001
Ruppert et al. (2012) [222]		Hypertension	33	21%	70.6 (9.1)	Prospective	MEMS for 6 weeks post-BMQ	Necessity (5) Concerns (5)	0.501 0.254	0.306 0.053
Russell &	NZ	Depression	85	28%	43.7 (11.5)	Cross-sectional	5-item MARS	Necessity (5)	1.115	0.786

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
Kazantzis (2008) [223]										
Schoenthaler et al. (2012) [224]	USA	Type II Diabetes	608	48%	62.1 (9.2)	cross-sectional	MPR over last 2 years	Concerns (14) Necessity (5)	0.269 0.757	0.002 0.060
Schuz et al. (2011) [225]	GMY	Older Adults with Comorbid Illnesses	309	59.3%	73.3 (5.1)	Longitudinal	2 items from RAM	Concerns (5) Necessity (2) Concerns (2)	0.878 1.353 0.590	0.380 0.155 0.014
Shiyabola & Nelson (2011) [226]	USA	Diabetes	16	0%	46.1 (10.2)	Cross-sectional	4-item MMAS	Necessity (5) Concerns (5)	0.917 1.539	0.931 0.671
Sirey et al. (2013) [227]	USA	Older Adults with Comorbid Illnesses	299	22.1%	Nonadherent 75.6 (7.3); Adherent 76.7 (7.4)	Cross-sectional	4-item MMAS	Necessity (5) Concerns (5)	1.182 0.494	0.435 0.001
Sofianou et al. (2012) [228]	USA	Asthma	242	16.1%	67.4 (6.8)	Cross-sectional	10-item MARS	Necessity (5) Concerns (5)	2.353 0.437	<0.001 0.001
Tibaldi et al., (2009) [229]	Italy	Chronic illness	427	45%	59 (14)	Cross-sectional	5-item MARS	Necessity (5) Concerns (6)	1.314 0.488	0.123 <0.001
Sud et al., (2005) [60]	USA	Acute Coronary Syndrome	208	60.6%	64.9 (13.0)	Cross-sectional	4-item MMAS	Necessity (5) Concerns (5)	1.800 0.720	0.022 0.198
Trachtenberg et al. (2012) [32]	USA, UK	Thalassemia	371	47.4%	24.0 (12.6)	Longitudinal	Self-reported number of doses taken in the past week and month 1) DFO 2) Oral iron chelator; serum ferritin, liver biopsy, liver iron concentration.	Necessity (5) Concerns (5)	0.694 0.964 1.115 0.720	0.256 0.910 0.633 0.152
Treharne et al. (2004) [230]	UK	Rheumatoid Arthritis	85	25%	58.9 (12.64)	Cross-sectional	1) 19-item CQR 2) 2 items from the MARS ^c	Necessity (5) Concerns (5)	31.758 0.621	<0.001 0.239
Unni & Farris (2011)a [33]	USA	Cholesterol Loweing Medication or Asthma Maintenance Medication Patients	420	54.4%	Cholesterol: 59.4; Asthma: 48.7	Cross-sectional	Medication Adherence Reasons Scale (4 types of non-adherence for each medication combined into any or none)	Necessity (5) Concerns (5)	0.981 0.265 1.714	0.925 <0.001 0.004
Unni & Farris (2011)b [27]	USA	Older Adults	1061	45.6%	Adherent: 73.2 (9.2) Non-adherent: 72.5 (5.5)	Cross-sectional (two time points)	4-item MMAS 1) time 1; 2) time 2	Necessity (5) Concerns (5)	1.010 0.462	0.931 <0.001
Uusküla et al.	EST	HIV	161	55%	≤30 N = 45	Cross-sectional	Recall of proportion of	Necessity (6)	1.516	0.442

Table 1. Cont.

Author and date	Country	Illness Group	N	% male	Mean age (SD)	Study Design	Adherence measure	BMQ (number of items)	OR	p
(2012) [231]			>30	N=82		sectional	total doses prescribed taken during past 3 days	Concerns (7)	0.250	0.073
Van den Bemt et al. (2009) [232,233]	NL	Rheumatoid Arthritis	228	33%	56.2 (12.2)	Cross-sectional	Self-report	Necessity (5)	1.516	0.442
Voils et al. (2012) [233]	USA	Hypertension	201	86%	64.1 (11.0)	Cross-sectional	8-item MMAS	Necessity (5)	1.516	0.442
Wileman et al. (2011) [234]	UK	End-Stage Renal Disease	76	60.5%	63.1 (15.4)	Cross-sectional	Medications adherence questionnaire (MAO) plus serum phosphate level >= 1.8 mmol/l	Concerns (5)	0.392	<0.001
Wong & Mulherin (2007) [235]	UK	Rheumatoid Arthritis	68	40%	55.8 (13.0)	Longitudinal	Patient report of drug continuation at 1 year versus discontinuation ^b	Necessity (5)	1.319	0.568
Yu et al. (2012) [236]	SGP	Peritoneal Dialysis	20	60%	64.4 (11.6)	Cross-sectional	Specially designed 5 item scale with 5 non-adherent behaviours, rated on 5 point Likert scale plus serum phosphate > 1.78 mmol/l	Concerns (5)	0.870	0.774
Zerah et al. (2012) [237]	FRA	Patients taking Glucocorticoids	182	21%	Median 47 [range 33–61]	Cross-sectional	4-item MMAS	Necessity (5)	2.008	0.042
								Concerns (5)	0.484	0.035

Note. NZ = New Zealand; IRE = Ireland; NTL = Netherlands; CAN = Canada; FRA = France; SWE = Sweden; IRN = Iran; SWZ = Switzerland; ESP = Spain; DMK = Denmark; EGT = Egypt; SGP = Singapore; JPN = Japan; EST = Estonia; GMY = Germany; AUS = Australia; IBD = inflammatory bowel disorder; TIA = Transient Ischemic Attack; MARS is the Medication Adherence Rating Scale from Thompson, Kulkarni, & Sergejew (2000); MEMS is Medication Event Monitoring System; CO-R is the Compliance Questionnaire-Rheumatology from de Klerk, van der Heijde, Landewé, van der Linden (2003); MMAS is the Morisky Medication Adherence Scale from Morisky, Green, & Levine (1986); TxEQ is the Transplant Effects Questionnaire from Ziegelmann et al. (2002); ACTG is the Adherence to Combination Therapy Guide from Chesney et al., 2000; RAM is the Reported Adherence to Medication Scale from Horne et al., (1999), renamed MARS (Medication Adherence Report Scale); VAS = visual analogue scale.

^aAdherence result selected for use in meta-analysis;

^bAdherence measure dichotomised into adherent and nonadherent groups;

^cRelationship between adherence measure and BMQ scales not reported.

doi:10.1371/journal.pone.0080633.t001

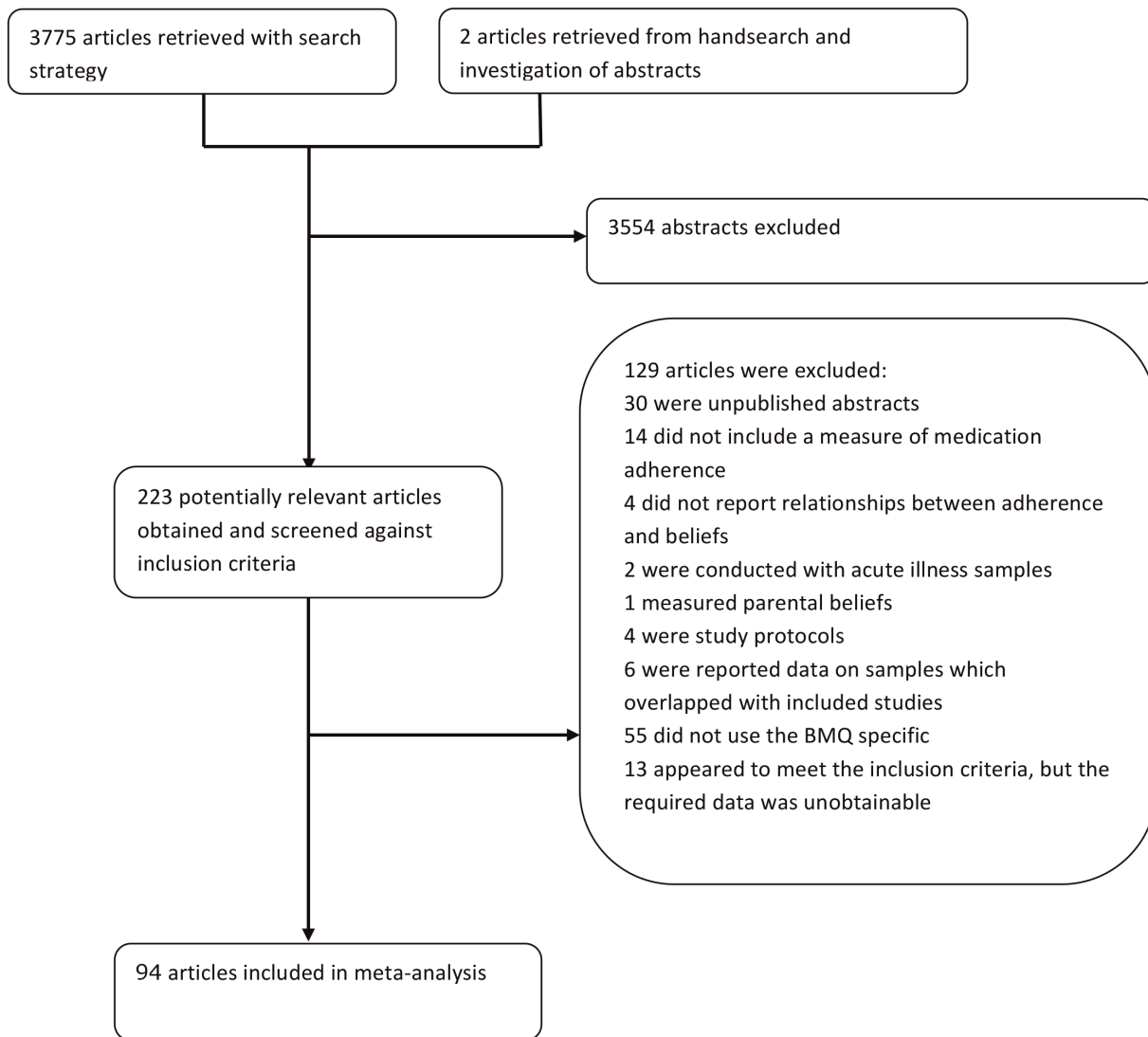


Figure 1. Selection process for study inclusion.
doi:10.1371/journal.pone.0080633.g001

Necessity and Concerns items included (since items may be added specific to the medication prescribed), the adherence measure used, information (means and standard deviations, odds ratios and 95% confidence intervals or correlation coefficients) to calculate the effect size between adherence and Necessity beliefs and Concerns, and the p-value. Where the full required statistics were not reported, authors were contacted for further information.

Methodology/Quality Assessment

A simple methodology assessment tool was devised for this study. Methodology was assessed by two of three independent expert raters (SC, RP and VC) using the following parameters:

- study location (UK or non-UK)
- study design (cross-sectional or longitudinal/prospective)
- measure of adherence (self-report or objective measure [electronic monitors, prescription redemption, blood test results]).

- sample size ($<82 = 0$ or $\geq 82 = 1$). This was based on the sample needed to detect a medium effect size for a correlation ($r = 0.3$) with an alpha level of 0.05 and 80% power.

Ratings were completed independently and then combined. There were no disagreements regarding ratings.

Statistical Analysis

The primary outcome measure was adherence to medication. For each study, the effect size was expressed as an odds ratio with 95% confidence intervals. Where studies reported the standard mean difference or correlation coefficient, the effect size was converted into an odds ratio, using the Comprehensive Meta-Analysis program. We used a random effects model to accommodate heterogeneity between studies which was anticipated due to differences with respect to sample characteristics, study design and the adherence measure used.

The presence of significant heterogeneity across studies was examined using the chi-squared statistic (Q). The magnitude of this heterogeneity across studies was estimated using the I^2 statistic

[34], which assesses the percentage of variance among studies which is not due to chance.

Sensitivity analyses were conducted to ascertain whether the effect sizes seen were robust when individual studies, or studies grouped based on the methodological factors described above were excluded.

Orwin's fail-safe N [35,36] was calculated to estimate the number of unpublished studies necessary to reverse any conclusion that a significant effect exists (based on the conservative assumption that unpublished studies would have effect sizes of equal magnitude but opposite direction to the overall effect size in this meta-analysis). Egger's t-test and funnel plots were also used to test for publication bias, in line with recent recommendations [37].

Results

Selection of Studies

Ninety-four percent (3554) of the 3775 studies retrieved were rejected after checking the titles and abstracts against the selection criteria above (Figure 1). 223 relevant articles were identified. A search of the reference lists of these articles revealed one further relevant study [38].

Of the 223 studies identified, a further 129 were excluded (Figure 1). Thirty of these were unpublished studies and conference proceedings. These were investigated further and authors were contacted where necessary to clarify whether unpublished work had led to publications [39–45]. Sixteen studies [44,46–59] [60] had since been published, fifteen of which already formed part of the included list and one additional eligible study was available online early [61]. Six papers reported data on samples which overlapped with included studies [62–67], and four were protocols for ongoing studies [68–71].

Thirteen studies were excluded because they did not include a measure of medication adherence [72–85]. Two of these included separate assessment modes for intentional and unintentional adherence but no overall adherence assessment [80,85]. Fifty-five studies did not use the BMQ Specific scales [86–140]. Four studies were excluded because the relationship between treatment beliefs and adherence behaviour was not reported [24,141–143]. Two articles were conducted in acute rather than long-term condition samples (influenza [144] and antibiotic use [145]) and one article was excluded because *parental* beliefs about medicine were measured [146]. Thirteen studies study met the inclusion criteria but the article did not contain the required statistical information. We contacted the authors but were unable to obtain the relevant data [38,147–158]. Thus, once screened against the inclusion criteria, 94 articles were retained for inclusion in the meta-analysis. Table 1 provides a summary of each of the studies included in the meta-analysis.

Three of the included studies [16,159,160] reported associations between adherence and Necessity beliefs, but not Concerns. The authors of these articles were contacted, but the data for Concerns was unavailable. Two studies [32,33] reported two largely non-overlapping samples for both Necessity beliefs and Concerns. Thus, data for 91 studies and 93 comparisons for Concerns, and data for 94 studies and 96 comparisons for Necessity beliefs, were included in the meta-analysis.

Sample Characteristics

The mean age of participants in the 94 included studies ranged from 24.0 to 74.2, with an overall mean age of 55.8 (it was not possible to calculate the mean age in 13 studies). The percentage of males ranged from 0–100% (breast cancer and haemophilia samples respectively), with an overall percentage of males of

49.7% male (excluding 3 studies where it was not possible to calculate the number of males). Sample sizes ranged from 16 to 1871.

The total sample, $N=25,072$, encompassed patients with asthma, renal disease, organ transplantation, dialysis chronic pain, kidney transplantation, cancer, cardiovascular disorders, Marfan's syndrome, depression, haemophilia, diabetes, HIV, rheumatoid arthritis, osteoporosis, thalassemia, inflammatory bowel disease, bipolar disorder, schizophrenia, epilepsy, migraine, back problems, glaucoma and mixed chronic illness.

Thirty-three studies (35.1%) used the MARS to measure adherence, 20 used the Morisky Medication Adherence Scale (21.2%), 3 used pharmacy refill (3.2%), 3 used electronic monitoring (3.2%) and two or fewer studies used the remaining measures.

Effect Sizes

Necessity beliefs. There was a significant relationship between Necessity beliefs and adherence, $OR=1.742$, 95% CI [1.569, 1.934], $p<0.0001$. There was significant heterogeneity between the 96 comparisons from 94 studies, $Q(95)=422.662$, $p<0.001$, which was substantial in magnitude, $I^2=77.52\%$.

Figure 2 presents the individual effect-size estimates and shows that the relationship between Necessity beliefs and adherence was significant ($p<0.05$) for 49 (51.0%) of the included studies. Sensitivity analyses revealed that the overall result was not affected when any single finding was omitted.

Concerns. There was a significant relationship between Concerns and adherence and fewer Concerns about adverse effects, $OR=0.502$, 95% CI: [0.450, 0.560], $p<0.0001$. There was significant heterogeneity among the 93 comparisons from 91 studies, $Q(92)=481.84$, $p<0.001$, suggesting that factors other than chance accounted for a moderate-substantial amount of variance, $I^2=80.91\%$.

Figure 3 presents the individual effect-size estimates and shows that the relationship between concerns and adherence was significant ($p<0.05$) for 53 (57.0%) of the included studies. Sensitivity analyses revealed that the overall result did not change when any single finding was omitted.

Stratification by Long-Term Condition and Measurement

See Tables 2 and 3 for OR stratified by different long-term conditions and adherence measures. Two few studies reported data on the majority of conditions and measures to allow statistical tests for heterogeneity.

Methodology/Quality Assessment

See Table 4 for sensitivity analyses.

Study location. Most studies were conducted outside of the UK ($n=62$; 66.0%). Stronger effects were apparent for both Necessity and Concerns for studies conducted in the UK relative to studies conducted outside of the UK, however the relationship between Necessity and Concerns was significant for both locations. Substantial and significant heterogeneity was present in all analyses.

Study design. The majority of studies ($n=77$, 81.9%) were cross-sectional, with few studies using longitudinal or prospective designs ($n=17$; 18.1%). Effect sizes were similar for longitudinal/prospective and cross-sectional designs for both Necessity and Concerns. Substantial and significant heterogeneity was present in all analyses.

Measurement of adherence. Eighty-three studies (88.3%) employed measured adherence using self-report, while 11 (11.7%) used other methods. The association between adherence and

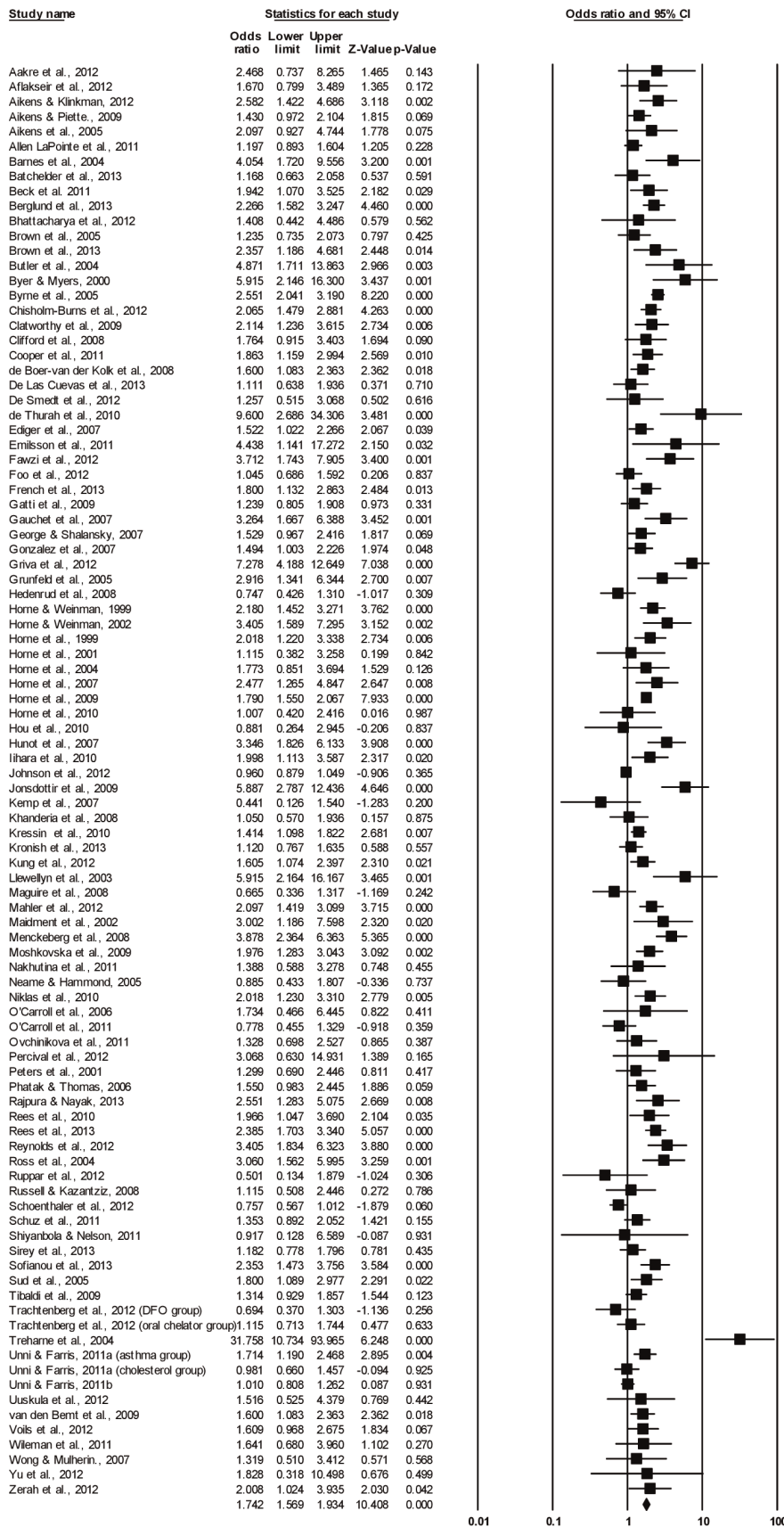


Figure 2. Forest plot of effect sizes for BMQ Necessity and medication adherence. doi:10.1371/journal.pone.0080633.g002

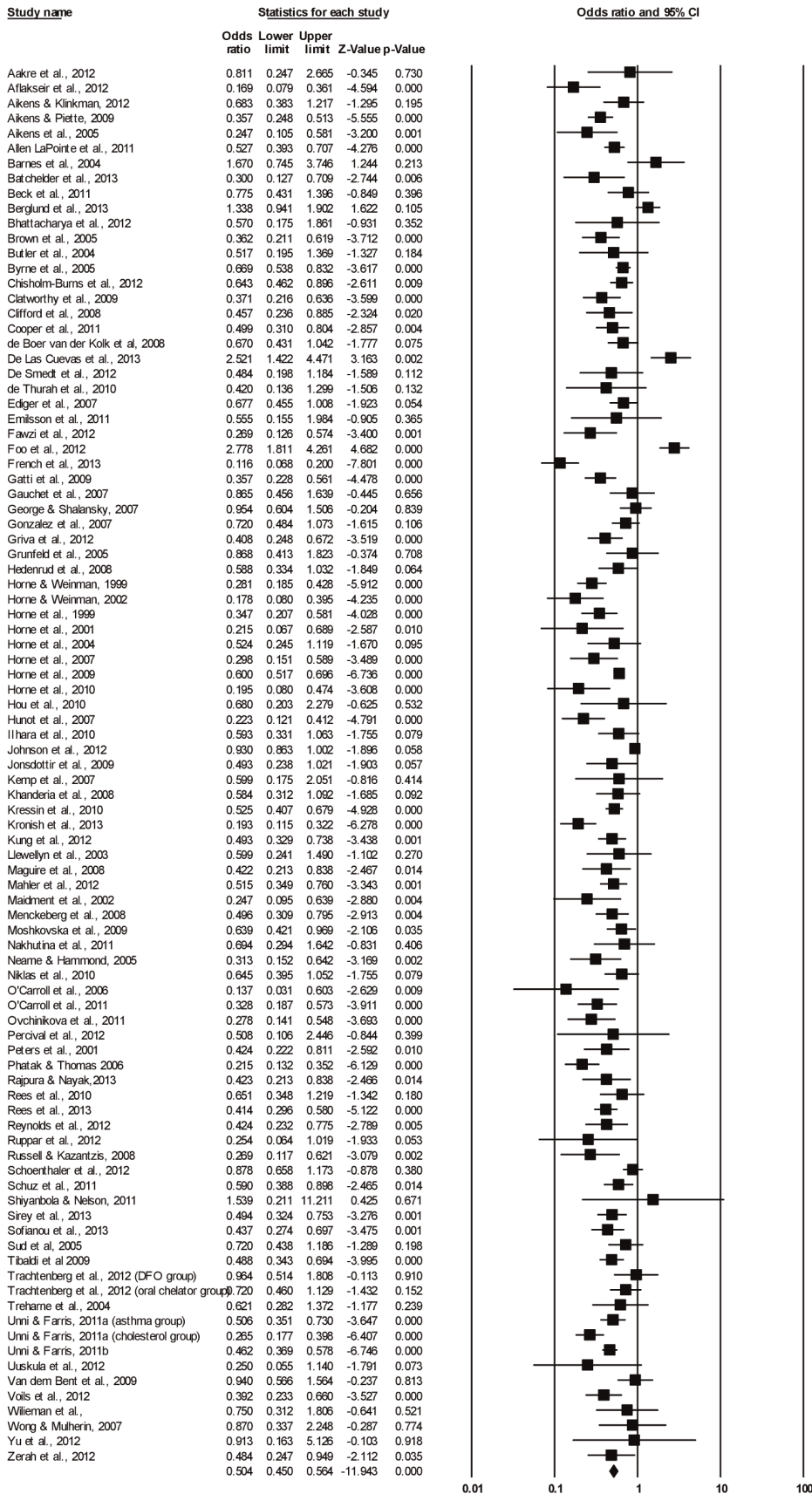


Figure 3. Forest plot of effect sizes for BMQ Concerns and medication adherence. doi:10.1371/journal.pone.0080633.g003

Table 2. Analyses Stratified By Long-Term Condition.

	<i>k</i>	<i>OR</i>	(95% CI)	<i>p</i>
Necessity				
Asthma	7	2.610	1.802–3.780	<0.001
Bipolar disorder	2	1.624	0.739–3.567	0.227
Blood disorders	3	1.512	0.580–3.944	0.398
Cancer	2	2.313	1.190–4.496	0.013
Depression	8	1.989	1.382–2.862	<0.001
Diabetes	6	1.502	0.930–2.425	0.096
Dialysis/end stage renal disease	3	1.454	0.771–2.742	0.247
Epilepsy	2	0.859	0.284–2.602	0.789
Glaucoma	3	1.697	0.976–2.949	0.061
High cholesterol	2	1.497	0.659–3.401	0.335
HIV	9	1.742	1.242–2.444	0.001
Hypertension	7	1.426	0.980–2.075	0.064
IBD	3	1.775	1.560–2.020	<0.001
Mixed sample	11	1.504	1.249–1.810	<0.001
Organ transplant	5	2.875	1.561–5.294	0.001
Pain	2	1.239	0.468–3.280	0.666
Rheumatoid arthritis	5	3.277	1.106–9.708	0.032
Schizophrenia	2	3.301	1.115–9.777	0.031
Stroke/CHD/acute coronary syndrome	9	1.402	1.022–1.924	0.036
Concerns				
Asthma	6	0.406	0.304–0.541	<0.001
Bipolar disorder	2	0.410	0.250–0.672	<0.001
Blood disorders	3	0.764	0.545–1.073	0.121
Cancer	2	0.771	0.411–1.445	0.417
Depression	8	0.408	0.215–0.772	0.006
Diabetes	6	0.450	0.202–1.003	0.051
Dialysis/end stage renal disease	3	0.509	0.211–1.232	0.134
Epilepsy	2	0.662	0.327–1.339	0.251
Glaucoma	3	0.909	0.258–3.204	0.882
High cholesterol	2	0.598	0.123–2.918	0.525
HIV	9	0.619	0.465–0.824	0.001
Hypertension	6	0.433	0.340–0.552	<0.001
IBD	3	0.612	0.536–0.698	<0.001
Mixed sample	11	0.423	0.339–0.501	<0.001
Organ transplant	4	0.486	0.356–0.503	<0.001
Pain	2	0.620	0.428–0.897	0.011
Rheumatoid arthritis	5	0.608	0.385–0.962	0.033
Schizophrenia	2	0.648	0.410–1.025	0.063
Stroke/CHD/acute coronary syndrome	9	0.518	0.382–0.704	<0.001

Note. CHD = coronary heart disease.
doi:10.1371/journal.pone.0080633.t002

Concerns was smaller, but still significant, when objective measures were used, and the heterogeneity around this estimate was small. The association between Necessity beliefs and adherence did not differ if objective or subjective adherence measures were used. Heterogeneity around the subjective measures estimates and the objective Necessity estimate was substantial.

Table 3. Analyses Stratified by Adherence Measure.

	<i>k</i>	<i>OR</i>	(95% CI)	<i>p</i>
Necessity				
Brief Medication Questionnaire	2	2.350	1.122–4.341	0.022
CQ-R	2	18.327	5.696–58.967	<0.001
Electronic monitoring	3	1.625	0.599–4.412	0.340
MARS	33	1.838	1.581–2.137	<0.001
MASRI	2	2.048	1.390–3.018	<0.001
MMAS	20	1.558	1.305–1.862	<0.001
Pharmacy refill	3	1.668	0.684–4.066	0.260
Concerns				
Brief Medication Questionnaire	2	0.415	0.131–1.321	0.137
CQ-R	2	0.546	0.286–1.044	0.067
Electronic monitoring	3	0.620	0.403–0.946	0.027
MARS	31	0.425	0.362–0.500	<0.001
MASRI	2	0.410	0.251–0.669	<0.001
MMAS	20	0.590	0.426–0.817	0.002
Pharmacy refill	3	0.785	0.630–0.979	0.031

Note. CQ-R = Compliance Questionnaire- Rheumatology from de Klerk, van der Heijde, Landewé, van der Tempel, & van der Linden (2003), MARS = Medication Adherence Report Scale Scale from Home et al., (1999), MASRI = Medication Adherence Self-Report Index from Walsh et al., 2002, MMAS = Morisky Medication Adherence Scale from Morisky, Green, & Levine (1986).
doi:10.1371/journal.pone.0080633.t003

Statistical power. Eighteen (19.1%) of the studies were classed as having small samples (less than 82). The size of the associations between Necessity and Concerns and adherence were similar for smaller and larger studies. Heterogeneity estimates indicated that variability around the larger samples estimates was substantial. However, the smaller sample estimates were less heterogeneous, with I^2 values in the small range for Concerns and the moderate range for Necessity beliefs.

Assessment of Risk of Publication Bias

Necessity. The fail-safe $N(N_f)$ was 96, indicating that there would need to be ≥ 96 unpublished findings of an equal magnitude but opposite direction, to reverse our conclusion that a significant effect exists. Inspection of the funnel plot suggested asymmetry (see Figure 4), however Duval and Tweedie's trim and fill method did not suggest that studies should be added/removed. Egger's t-test was significant, $t(94) = 1.60$, $p < 0.001$, suggesting the presence of asymmetry.

Concerns. The fail-safe $N(N_f)$ was 94, indicating that there would need to be ≥ 94 unpublished findings of an equal magnitude but opposite direction, to reverse our conclusion that a significant effect exists. Funnel plot inspection suggested the presence of asymmetry (see Figure 5), which was confirmed by a significant Egger's t-test, $t(91) = 1.80$, $p < 0.001$. Further, Duval and Tweedie's trim and fill method suggested 13 studies should be added/removed to make the funnel plot symmetrical. The location of the imputed studies indicated that the asymmetry may arise from a lack of reporting of studies which find a negative relationship between concerns and adherence. However, the similarity between the adjusted *OR* 0.567 95% CI [0.507, 0.634], which includes the imputed trimmed and filled studies, and the observed *OR* 0.504 95% CI [0.450, 0.564], suggests that any bias does not have a large impact on the findings.

Table 4. Analyses Stratified By Adherence Measure, Study Location, Design and Power.

	<i>k</i>	<i>OR</i>	(95% CI)	<i>p</i>	<i>I</i> ²	Heterogeneity test
Necessity						
UK study	32	2.201	1.786–2.713	<0.001	72.72%***	Q(1) = 7.67, <i>p</i> < 0.05
Non-UK study	64	1.573	1.405–1.761	<0.001	74.79%***	
Concerns						
UK study	31	0.403	0.335–0.485	<0.001	62.75%***	Q(1) = 7.61, <i>p</i> < 0.05
Non-UK study	62	0.555	0.486–0.635	<0.001	82.48%***	
Necessity						
Subjective adherence measure	83	1.737	1.565–1.929	<0.001	75.54%***	Q(1) = 0.031, <i>p</i> = 0.86
Objective adherence measure	13	1.817	1.114–2.963	0.017	86.20%***	
Concerns						
Subjective adherence measure	81	0.485	0.429–0.549	<0.001	82.84%***	Q(1) = 13.55, <i>p</i> < 0.001
Objective adherence measure	12	0.726	0.609–0.866	<0.001	8.93%	
Necessity						
Prospective/longitudinal	18	1.526	1.243–1.874	<0.001	63.02***	Q(1) = 1.82, <i>p</i> = 0.18
Cross-sectional	78	1.798	1.595–2.027	<0.001	79.49%***	
Concerns						
Prospective/longitudinal	18	0.449	0.356–0.567	<0.001	70.88%***	Q(1) = 1.14, <i>p</i> = 0.29
Cross-sectional	75	0.519	0.458–0.588	<0.001	81.28%***	
Necessity						
Low power	18	1.848	1.290–2.646	0.001	46.19%*	Q(1) = 0.12, <i>p</i> = 0.73
High power	78	1.730	1.550–1.930	<0.001	80.16***	
Concerns						
Low power	17	0.488	0.371–0.643	<0.001	0.00%	Q(1) = 0.05, <i>p</i> = 0.82
High power	76	0.505	0.448–0.570	<0.001	83.83%***	

Note. **p* < .05, ****p* < .001 for Q statistic.
doi:10.1371/journal.pone.0080633.t004

Discussion

This meta-analytic review indicates that the Necessity-Concerns Framework (NCF) is a potentially useful model for understanding patients' evaluations of prescribed medicines. The magnitude of the aggregate effect sizes indicates that, for each standard deviation increase in Necessity beliefs, the odds of adherence increases by a factor of 1.7. Conversely, for each standard deviation increase in Concerns, the odds of adherence decreases by a factor of 2.0.

Strengths and Limitations of the Study

The sensitivity and publication bias analyses conducted confirm our hypothesis that Necessity beliefs and Concerns are associated with adherence/nonadherence to medicines, across a wide range of conditions, medications, and study locations. No research synthesis can transcend the limitations of the primary studies. However, sensitivity analyses confirmed that this association is robust across methodological features; remaining when small, underpowered studies were removed, when only longitudinal/prospective designs were included, and when self-report and non self-report adherence assessments were included separately. The majority of the studies relied solely on self-reported adherence. Self-report measures have high face validity and high specificity for nonadherence, however they may be subject to self-presentation and recall bias [161]. Thus some people may be reporting higher adherence rates than they actually attain. This bias does not

diminish our confidence in the finding that beliefs were related to adherence, as there is no evidence that such a bias would be associated with medication beliefs. Indeed some patients with high Concerns and low Necessity beliefs may be expected to incorrectly report high adherence in order to present themselves positively. This pattern would attenuate the relationship found between adherence and medication beliefs, making it less likely that we would find an association between beliefs and adherence. Moreover, given that this relationship remained when non-self report measures were used, we are confident that the observed relationships between beliefs and adherence are not an artifact arising from the limitations of self-report. Only published studies were included, creating a possible bias, since studies submitted for publication may be more likely to have positive results and larger effect sizes. Since for both Necessity beliefs and Concerns, the fail safe N indicated that the number of additional negative findings required to accept our null hypothesis was similar to the number of studies included in this meta-analysis, and there was little suggestion of publication bias through funnel plot analysis, our findings appear to reflect a true relationship between beliefs and adherence.

Stratifying by long-term condition and adherence measurement revealed a need for further studies using objective measures, and highlighted some conditions, for example epilepsy and functional pain syndromes where further research is needed. We do not know whether the Necessity-Concerns Framework will be of equal utility across medications administered by different routes e.g. depot

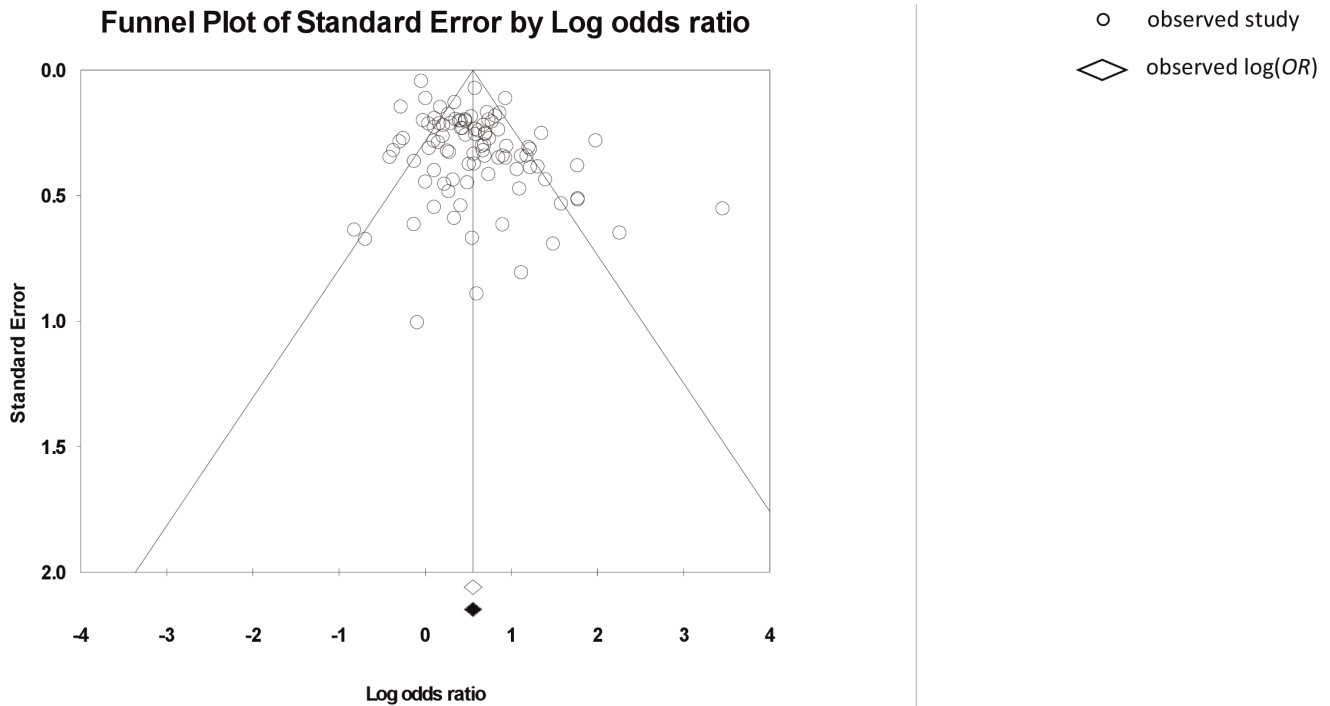


Figure 4. Funnel plot for BMQ Necessity and medication adherence.
doi:10.1371/journal.pone.0080633.g004

injections, or if practical barriers to care may be of relatively greater importance in some groups using medications administered through different routes.

Eighteen studies assessed whether Concerns and Necessity beliefs could predict adherence using longitudinal/prospective designs. The relationship was not reduced in these studies, supporting the proposal that medication beliefs can influence

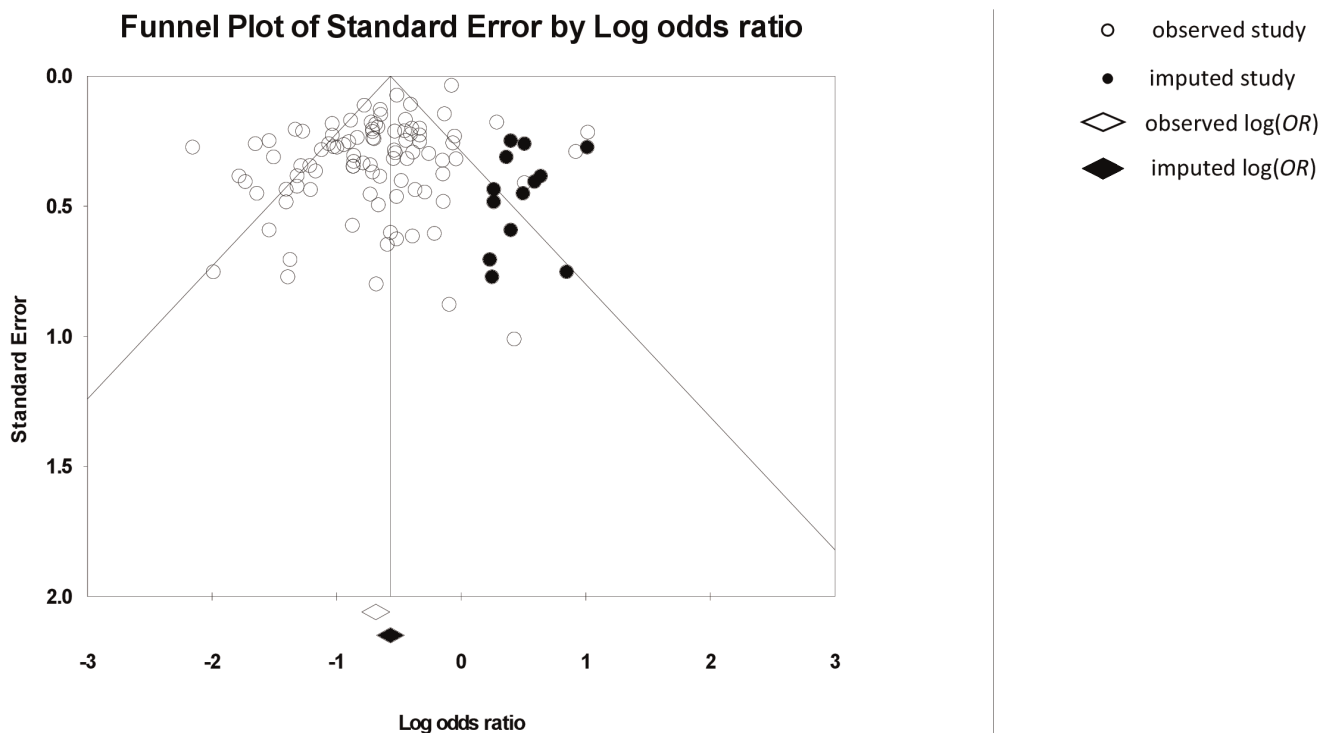


Figure 5. Funnel plot for BMQ Concerns and medication adherence.
doi:10.1371/journal.pone.0080633.g005

later adherence as part of the self-regulation of illness [14]. We did not restrict our inclusion criteria to studies published in English. However, our search only identified one study published in any other language, despite the fact that the BMQ was translated into the native language for the study. Cultural values [162] can impact on the way in which individuals interact with the healthcare system. However, variations in treatment necessity and concerns and association between these beliefs and adherence were noted across different countries, languages and cultures. We found that studies outside the UK, where the BMQ and its disease-specific modifications have been predominantly developed, found reduced associations between necessity and concerns beliefs and adherence. Further work is needed to investigate potential cultural variations in medication beliefs.

Implications for Research and Practice

The development of more effective methods for addressing nonadherence is a priority for research and practice [1,5]. Our findings suggest, that novel interventions to support informed choice and optimal adherence to appropriately prescribed medicines are likely to be more effective if they take account of patients' beliefs about the treatment and how they judge their personal need for the prescription relative to concerns about potential adverse consequences of taking it. Necessity beliefs and Concerns may trigger intentional nonadherence, for example, if patients decide not to take their medication due to concerns regarding potential or actual adverse consequences, and unintentional nonadherence, (e.g. if patients who believe a medicine is not important for their health forget to take it). Beliefs can have counter-balancing effects on adherence, such as when patients continue to take a medication they believe is essential for their health despite concerns regarding adverse effects¹⁵. The challenge now is to develop effective interventions to address patients' doubts about the necessity for treatment and concerns about adverse consequences in order to enhance adherence. The challenge goes beyond 'getting patients to take more medicines'. Our findings show that many patients harbour significant, unresolved doubts and concerns about prescribed treatment suggesting a fault-line between patients' and prescribers' cultural perceptions of the treatment. Viewed from the perspective of biomedicine, non-adherence may seem irrational. However, from the patients' perspective, nonadherence may be a 'common-sense' response to their implicit appraisal of the treatment. For some patients nonadherence might represent an *informed* choice. In this case the outcome of 'adherence support' would be to avoid prescribing an unwanted treatment, to the relief of patient and payer. However, for others, evaluations of treatment necessity and concerns may be based on misconceptions about the illness and treatment.

More detailed studies of patient representations illness and treatment show that, even when treatment evaluations are based on misconceptions they appear to draw on a 'common-sense' logic [12,163,164]. For example, the need for daily medication may

seem less salient when symptoms are absent or cyclical [165–167]. Concerns about prescribed medication are not just related to side effects but are common, even when the medication is well tolerated. They are often related to beliefs about the negative effects of medication and include worries about long-term effects, dependence, cost of medication and dislike of having to rely on medicines [14,167]. Concerns are related to more general beliefs about pharmaceuticals as a class of treatment which are often perceived as intrinsically harmful and over-prescribed by doctors [167,168]. The package information leaflets, dispensed with many prescription medicines may exacerbate concerns as they list all possible side effects, leaving patients with outstanding questions and making it difficult to understand the likely risk and place them in context with potential benefits [169].

Nonadherence is often a hidden problem. Patients may be reluctant to express doubts or concerns about prescribed medication and to report nonadherence; sometimes because they fear that this will be perceived by the prescriber as a lack of faith in them. The first step to facilitating adherence is therefore to take a 'no-blame approach' and encourages an honest and open discussion to identify nonadherence and the reasons for non-adherence [1]. Adherence support should be tailored to the needs of the individual addressing perceptions (e.g. necessity beliefs and concerns) as well as practicalities (e.g. capacity and resources). This can be approached in a three stage process: 1) communicating a common-sense rationale for personal need that takes account of the patient's perceptions of the illness and symptoms expectations and experiences 2) eliciting and addressing specific concerns and 3) making the treatment as convenient and as easy to use as possible. Interventions attempting to improve adherence by applying these approaches have had encouraging results [142,170]. Nonadherence remains a fault-line in clinical practice. Consideration of patients' perceptions of treatment necessity and concerns in prescribing and treatment review is essential to support informed choice and optimal adherence to appropriately prescribed treatment.

Supporting Information

Supporting Information S1 PRISMA Checklist.
(DOC)

Acknowledgments

We would like to thank Christina Jackson for her help with the publication bias analysis, and the authors who sent additional data for their assistance.

Author Contributions

Analyzed the data: VC RH RP SC AF NF. Wrote the paper: RH VC RP SC. Conceived and designed the study: RH. Acquired the data: RP SC VC. Critically revised the manuscript for important intellectual content: RH SC RP NF AF VC.

References

1. National Institute for Health and Clinical Excellence (2009) Medicines adherence: involving patients in decisions about prescribed medicines and supporting adherence CG76. London: National Institute for Health and Clinical Excellence.
2. World Health Organisation (2003) Adherence to Long-term Therapies: Evidence for Action. Geneva: World Health Organisation.
3. Simpson SH, Eurich DT, Majumdar SR, Padwal RS, Tsuyuki RT, et al. (2006) A meta-analysis of the association between adherence to drug therapy and mortality. *BMJ* 333: 15.
4. Horne R, Weinman J, Barber N, Elliott RA, Morgan M (2006) Concordance, Adherence and Compliance in Medicine Taking: A conceptual map and research priorities. London: National Institute for Health Research (NIHR) Service Delivery and Organisation (SDO) Programme. Available: <http://www.sdo.lshtm.ac.uk/sdo762004.html>. Accessed October 17th 2013.
5. Haynes RB, Yao X, Degani A, Kripalani S, Garg A, et al. (2005) Interventions to enhance medication adherence. *Cochrane Database Syst Rev*: CD000011.
6. Weinman J, Petrie KJ, Moss-Morris R, Horne R (1996) The illness perception questionnaire: A new method for assessing the cognitive representation of illness. *Psychology & Health* 11: 431–445.
7. Horne R, Weinman J (1999) Patients' beliefs about prescribed medicines and their role in adherence to treatment in chronic physical illness - processes and applications. *Journal of Psychosomatic Research* 47: 555–567.
8. Benedetti F, Carlino E, Pollo A (2011) How placebos change the patient's brain. *Neuropsychopharmacology* 36: 339–354.

9. Colloca L, Benedetti F (2007) Nocebo hyperalgesia: how anxiety is turned into pain. *Current Opinion in Anesthesiology* 20: 435–439.
10. Horne R (2001) Compliance, adherence and concordance. In: Taylor K, Harding G, editors. *Pharmacy Practice*. London: Taylor and Francis. 165–184.
11. De Maeseneer J, Roberts RG, Demarzo M, Heath I, Sewankambo N, et al. (2012) Tackling NCDs: a different approach is needed. *The Lancet* 379: 1860–1861.
12. Horne R (1997) Representations of medication and treatment: Advances in theory and measurement In: Petric KJ, Weinman JA, editors. *Perceptions of Health and Illness: Current Research and Applications*. London: Harwood Academic Press. 155–188.
13. Horne R (2003) Treatment perceptions and self regulation. In: Cameron LD, Leventhal H, editors. *The self-regulation of health and illness behaviour*. London: Routledge. 138–153.
14. Horne R, Weinman J, Hankins M (1999) The Beliefs about Medicines Questionnaire: The development and evaluation of a new method for assessing the cognitive representation of medication. *Psychology and Health* 14: 1–24.
15. Maidment R, Livingston G, Katona C (2002) Just keep taking the tablets: adherence to antidepressant treatment in older people in primary care. *International Journal of Geriatric Psychiatry* 17: 752–757.
16. Byer B, Myers LB (2000) Psychological correlates of adherence to medication in asthma *Psychology, Health and Medicine* 5: 389–393.
17. Byrne M, Walsh J, Murphy AW (2005) Secondary prevention of coronary heart disease: patient beliefs and health-related behaviour. *Journal of Psychosomatic Research* 58: 403–415.
18. Clatworthy J, Bowskill R, Parham R, Rank T, Scott J, et al. (2009) Understanding medication non-adherence in bipolar disorders using a Necessity-Concerns Framework. *Journal of Affective Disorders* 116: 51–55.
19. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, et al. (2000) Meta-analysis of Observational Studies in Epidemiology. *JAMA: The Journal of the American Medical Association* 283: 2008–2012.
20. Gonzalez J, Penedo F, Llabre M, Duran R, Antoni M, et al. (2007) Physical symptoms, beliefs about medications, negative mood, and long-term HIV medication adherence. *Annals of Behavioural Medicine* 34: 46–55.
21. de Thurah A, Norgaard M, Harder I, Stengaard-Pedersen K (2010) Compliance with methotrexate treatment in patients with rheumatoid arthritis: influence of patients' beliefs about the medicine. A prospective cohort study. *Rheumatol Int* 30: 1441–1448.
22. Llewellyn C, Miners A, Lee C, Harrington C, Weinman J (2003) The illness perceptions and treatment beliefs of individuals with severe haemophilia and their role in adherence to home treatment. *Health Psychology* 18: 185–2000.
23. French DP, Wade AN, Farmer AJ (2013) Predicting self-care behaviours of patients with type 2 diabetes: The importance of beliefs about behaviour, not just beliefs about illness. *J Psychosom Res* 74: 327–333.
24. Horne R, Clatworthy J, Hankins M, ASCOT Investigators (2010) High adherence and concordance within a clinical trial of antihypertensives. *Chronic Illness* 6: 243–251.
25. O'Carroll R, Whittaker J, Hamilton B, Johnston M, Sudlow C, et al. (2011) Predictors of adherence to secondary preventive medication in stroke patients. *Ann Behav Med* 41: 383–390.
26. Ovchinkova L, Smith L, Bosnic-Anticevich S (2011) Inhaler technique maintenance: gaining an understanding from the patient's perspective. *J Asthma* 48: 616–624.
27. Umri EJ, Farris KB (2011) Unintentional non-adherence and belief in medicines in older adults. *Patient Educ Couns* 83: 265–268.
28. Aikens JE, Nease DE Jr, Nau DP, Klinkman MS, Schwenk TL (2005) Adherence to maintenance-phase antidepressant medication as a function of patient beliefs about medication. *Annals of Family Medicine* 3: 23–30.
29. Johnson MO, Dilworth SE, Taylor JM, Darbes LA, Comfort ML, et al. (2012) Primary relationships, HIV treatment adherence, and virologic control. *AIDS Behav* 16: 1511–1521.
30. Batchelder AW, Gonzalez JS, Berg KM (2013) Differential medication nonadherence and illness beliefs in co-morbid HIV and type 2 diabetes. *J Behav Med*. doi: 10.1007/s10865-012-9486-1.
31. Allen LaPointe NM, Ou FS, Calvert SB, Melloni C, Stafford JA, et al. (2011) Association between patient beliefs and medication adherence following hospitalization for acute coronary syndrome. *Am Heart J* 161: 855–863.
32. Trachtenberg FL, Mednick L, Kwiatkowski JL, Neufeld EJ, Haines D, et al. (2012) Beliefs about chelation among thalassemia patients. *Health Qual Life Outcomes* 10: 148.
33. Umri E, Farris KB (2011) Determinants of different types of medication non-adherence in cholesterol lowering and asthma maintenance medications: a theoretical approach. *Patient Educ Couns* 83: 382–390.
34. Higgins J, Green S (2011) *Cochrane Handbook for Systematic Reviews of Interventions: The Cochrane Collaboration*. Available: <http://handbook.cochrane.org/>. Accessed 2013 Nov 10.
35. Orwin R (1983) A Fail-Safe N for effect size in meta-analysis. *Journal of Educational Statistics* 8: 157–159.
36. Rosenthal R (1979) The "file drawer problem" and tolerance for null results. *Psychological Bulletin* 85: 638–641.
37. Sterne JAC, Sutton AJ, Ioannidis JPA, Terrin N, Jones DR, et al. (2011) Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. *BMJ* 343.
38. Magadza C, Radloff SE, Srinivas SC (2009) The effect of an educational intervention on patients' knowledge about hypertension, beliefs about medicines, and adherence. *Research in Social and Administrative Pharmacy* 5: 363–375.
39. Aburuz SM, McElroy JC, Millership JS, Andrews WJ, Smyth S (2002) Factors affecting self-care activities, postprandial plasma glucose, and HbA1c in patients with type 2 diabetes. *International Journal Of Pharmacy Practice* 10S: 96.
40. Engova D, Duggan C, MacCallum P, Bates I (2004) The role of medication adherence in warfarin anticoagulation control and its cognitive determinants. *British Journal of Haematology Supplement* 1S: 57.
41. Engova D, Duggan C, MacCallum P, Bates I (2002) Patients' understanding and perceptions of treatment as determinants of adherence to warfarin treatment. *International Journal Of Pharmacy Practice* 10S: R69.
42. Kendrew P, Ward F, Buick D, Wright D, Horne R (2001) Satisfaction with information and its relationship with adherence in patients with chronic pain. *International Journal Of Pharmacy Practice* 9S: R5.
43. Skingle SJ (2004) A study to investigate factors that may be associated with patients' decisions about starting disease modifying anti-rheumatic drugs. *Rheumatology* 43S: 153.
44. Stafkey DR, Erickson SR, Kline-Rogers EM, Smith DE, Cooper JV, et al. (2003) Relationship between patient beliefs about medication and self-reported medication adherence six months after discharge for acute coronary syndromes. *Value in Health* 6: 312.
45. Wade AN, Farmer AJ, French DP (2004) Association of beliefs about illness and medication with self-care activities in noninsulin treated Type 2 diabetes. *Diabetic medicine Supplement* 21S: 52.
46. Rajpura JR, Nayak R (2010) The role of illness burden and medication beliefs in medication compliance of elderly with hypertension. *Value in Health* 3: A168.
47. Batchelder A, Berg K, Carter A, Gonzalez J (2010) Differences in treatment adherence, illness perceptions, and beliefs about medications in co-morbid HIV and type 2 diabetes mellitus. *Journal of the International Association of Physicians in AIDS Care* 9 (4): 253.
48. Chisholm-Burns M, Pinsky B, Parker G, Johnson P, Buzinec P, et al. (2010) Patient reported factors influencing adherence to antirejection medications. *American Journal of Transplantation* 10: 204.
49. Daleboudt GM, Broadbent E, McQueen F, Kaptein AA (2010) Intentional and unintentional treatment non-adherence in patients with systemic lupus erythematosus. *Lupus* 19: 167–168.
50. Gadkari A, McHorney C (2010) Prevalence and predictors of unintentional nonadherence among adults with chronic disease who self-identify as being adherent to prescription medications. *Value in Health* 3: A91.
51. McCann R, Jackson J, Stevenson M, Bickerstaff D, Cupples M, et al. (2010) Medication management in older people with visual impairment. *International Journal of Pharmacy Practice* 18: 95–96.
52. Moshkovska T, Mayberry J, Stone MA, Baker R, Bankart J, et al. (2010) The benefit of a tailored patient preference intervention in adherence to 5-ASA medication in ulcerative colitis: Results from a randomised controlled trial. *Gastroenterology* 1: S518.
53. Weinberger MI, Mercado M, Sirey JA (2010) Medication beliefs and adherence among community-dwelling older adults. *American Journal of Geriatric Psychiatry* 1: S111.
54. Wilke T, Mueller S (2010) Why do patients not adhere to prescribed medication regimes? Results of two German surveys. *Value in Health* 13 (7): A380.
55. Wisnivesky JP, Roy A, Lurslurchachai L, Li X, Leventhal H, et al. (2010) Complementary and alternative medication use and adherence to inhaled corticosteroid among inner-city asthmatics. *American Journal of Respiratory and Critical Care Medicine Conference: American Thoracic Society International Conference, ATS* 181.
56. Clerisme-Beaty EM, Wise RA, Bartlett SJ, Rand CS (2010) Outcome expectancy & medication adherence: "I think therefore I am". *American Journal of Respiratory and Critical Care Medicine Conference: American Thoracic Society International Conference, ATS* 181.
57. Foster JM, Smith L, Bosnic-Anticevich SZ, Usherwood T, Sawyer SM, et al. (2010) The beliefs and behaviours which predict objectively measured adherence to inhaled corticosteroids in asthma. *American Journal of Respiratory and Critical Care Medicine Conference: American Thoracic Society International Conference, ATS* 181.
58. Foster JM, Smith L, Bosnic-Anticevich SZ, Usherwood T, Sawyer SM, et al. (2010) Adherence with inhaled corticosteroids in asthma is predicted by beliefs, behaviours and side effects. *Respirology* 15: A29.
59. Harrold LR, Mazor KM, Peterson D, Firmino C, Yood RA (2010) Patient knowledge and beliefs concerning gout and its treatment. *Arthritis and Rheumatism* 62: 156.
60. Sud A, Kline-Rogers EM, Eagle KA, Fang J, Armstrong DF, et al. (2005) Adherence to medications by patients after acute coronary syndromes. *Annals of Pharmacotherapy* 39: 1792–1797.
61. Rajpura JR, Nayak R (2013) Role of Illness Perceptions and Medication Beliefs on Medication Compliance of Elderly Hypertensive Cohorts. *J Pharm Pract*. doi: 10.1177/0897190013493806.
62. Edmondson D, Horowitz CR, Goldfinger JZ, Fei K, Kronish IM (2013) Concerns about medications mediate the association of posttraumatic stress

- disorder with adherence to medication in stroke survivors. *Br J Health Psychol*. In press.
63. Manze M, Rose AJ, Orner MB, Berlowitz DR, Kressin NR (2010) Understanding racial disparities in treatment intensification for hypertension management. *J Gen Intern Med* 25: 819–825.
 64. Schuz B, Wurm S, Ziegelmann JP, Warner LM, Tesch-Romer C, et al. (2011) Changes in functional health, changes in medication beliefs, and medication adherence. *Health Psychol* 30: 31–39.
 65. Shiyabola OOFKB, Shiyabola OOSse (2010) Variation in patients' and pharmacists' attribution of symptoms and the relationship to patients' concern beliefs in medications. *Research in Social & Administrative Pharmacy* Vol6(4), Dec 2010, 334–344.
 66. Horne R, Faasse K, Cooper V, Diefenbach MA, Leventhal H, et al. (2013) The perceived sensitivity to medicines (PSM) scale: an evaluation of validity and reliability. *Br J Health Psychol* 18: 18–30.
 67. McHorney CA, Zhang NJ, Stump T, Zhao X (2012) Structural equation modeling of the proximal-distal continuum of adherence drivers. *Patient Prefer Adherence* 6: 789–804.
 68. Lopez-Torres J, Parraga I, Del Campo JM, Villena A (2013) Follow up of patients who start treatment with antidepressants: treatment satisfaction, treatment compliance, efficacy and safety. *BMC Psychiatry* 13: 65.
 69. O'Carroll R, Dennis M, Johnston M, Sudlow C (2010) Improving adherence to medication in stroke survivors (IAMSS): a randomised controlled trial: study protocol. *BMC Neurol* 10: 15.
 70. Timmers L, Boons CC, Mangnus D, Moes JE, Swart EL, et al. (2011) The use of erlotinib in daily practice: a study on adherence and patients' experiences. *BMC Cancer* 11: 284.
 71. Timmers L, Swart EL, Boons CC, Mangnus D, van de Ven PM, et al. (2012) The use of capecitabine in daily practice: a study on adherence and patients' experiences. *Patient Prefer Adherence* 6: 741–748.
 72. Gill A, de C. Williams AC (2001) Preliminary study of chronic pain patients' concerns about cannabinoids as analgesics. *Clinical Journal of Pain* 17: 245–248.
 73. Hobro N, Weinman J, Hankins M (2004) Using the self-regulatory model to cluster chronic pain patients: the first step towards identifying relevant treatments? *Pain* 108: 276–283.
 74. Horne R, Frost S, Hankins M, Wright S (2001) 'In the eye of the beholder': Pharmacy students have more positive perceptions of medicines than students of other disciplines. *International Journal Of Pharmacy Practice* 9: 85–89.
 75. Horne R, Graupner L, Frost S, Weinman J, Wright SM, et al. (2004) Medicine in a multi-cultural society: The effect of cultural background on beliefs about medications. *Social Science & Medicine* 59: 1307–1313.
 76. Jorgensen TM, Andersson KA, Mardby A-CM (2006) Beliefs about medicines among Swedish pharmacy employees. *Pharmacy World & Science* 28: 233–238.
 77. Ramstrom H, Afandi S, Elofsson K, Petersson S (2006) Differences in beliefs between patients and pharmaceutical specialists regarding medications. *Patient Education & Counseling* 62: 244–249.
 78. Gellaitry G, Cooper V, Davis C, Fisher M, Date HL, et al. (2006) Patients' perception of information about HAART: impact on treatment decisions. *AIDS Care* 17: 367–376.
 79. Kumar K, Gordon C, Toescu V, Buckley CD, Horne R, et al. (2008) Beliefs about medicines in patients with rheumatoid arthritis and systemic lupus erythematosus: a comparison between patients of South Asian and White British origin. *Rheumatology* 47: 690–697.
 80. Wray J, Waters S, Radley-Smith R, Sensky T (2006) Adherence in adolescents and young adults following heart or heart-lung transplantation. *Pediatric Transplantation* 10: 694–700.
 81. Aikens JE, Nease DE, Klinkman MS (2008) Explaining Patients' Beliefs About the Necessity and Harmfulness of Antidepressants. *The Annals of Family Medicine* 6: 23–29.
 82. Argentero P, Torchio E, Tibaldi G, Horne R, Clatworthy J, et al. (2010) The beliefs about drug treatment. The Italian version of the BMQ (the Beliefs about Medicines Questionnaire): its validity and applicability. [Italian] Le convinzioni sui trattamenti farmacologici. Validità e utilità della versione Italiana del BMQ (the Beliefs about Medicines Questionnaire). *Epidemiologia e psichiatria sociale* 19: 86–92.
 83. Allen LaPointe NM, Ou FS, Calvert SB, Melloni C, Stafford JA, et al. (2010) Changes in beliefs about medications during long-term care for ischemic heart disease. *Am Heart J* 159: 561–569.
 84. Tempier R, Hepp SL, Duncan C, Rohr B, Hachey K, et al. (2010) Patient-centered care in affective, non-affective, and schizoaffective groups: Patients' opinions and attitudes. *Community Mental Health Journal* 46: 452–460.
 85. Gadkari AS, McHorney CA (2012) Unintentional non-adherence to chronic prescription medications: how unintentional is it really? *BMC Health Serv Res* 12: 98.
 86. Burra TA, Chen E, McIntyre RS, Grace SL, Blackmore ER, et al. (2007) Predictors of Self-Reported Antidepressant Adherence. *Behavioral Medicine* 32: 127–134.
 87. Le TT, Bilderback A, Bender B, Wamboldt FS, Turner CF, et al. (2008) Do asthma medication beliefs mediate the relationship between minority status and adherence to therapy? *J Asthma* 45: 33–37.
 88. Mann D, Allegrante J, Natarajan S, Halm E, Charlson M (2007) Predictors of Adherence to Statins for Primary Prevention. *Cardiovascular Drugs and Therapy* 21: 311–316.
 89. McHorney CA, Schousboe JT, Cline RR, Weiss TW (2007) The impact of osteoporosis medication beliefs and side-effect experiences on non-adherence to oral bisphosphonates*. *Current Medical Research and Opinion* 23: 3137–3152.
 90. Perkins DO, Johnson JL, Hamer RM, Zipursky RB, Keefe RS, et al. (2006) Predictors of antipsychotic medication adherence in patients recovering from a first psychotic episode. *Schizophrenia Research* 83: 53–63.
 91. Schönnesson LN, Williams ML, Ross MW, Diamond PM, Keel B (2007) Three types of adherence to HIV antiretroviral therapy and their association with AIDS diagnosis, medication side-effects, beliefs about antiretroviral therapy, and beliefs about HIV disease. *International Journal of STD & AIDS* 18: 369–373.
 92. Talbot JT, Viall A, Direny A, de Rochars MB, Addiss D, et al. (2008) Predictors of Compliance in Mass Drug Administration for the Treatment and Prevention of Lymphatic Filariasis in Leogane, Haiti. *The American Journal of Tropical Medicine and Hygiene* 78: 283–288.
 93. van der Wal MHL, Jaarsma T, Moser DK, Veeger NJGM, van Gilst WH, et al. (2006) Compliance in heart failure patients: the importance of knowledge and beliefs. *European Heart Journal* 27: 434–440.
 94. Wang X, Wu Z (2007) Factors associated with adherence to antiretroviral therapy among HIV/AIDS patients in rural China. *AIDS* 21: S149–S155.
 95. Wetzel G, Nelemans P, van Wijk B, Broers N, Schouten J, et al. (2006) Determinants of poor adherence in hypertensive patients: Development and validation of the "Maastricht Utrecht Adherence in Hypertension (MUAH)-questionnaire". *Patient Education and Counseling* 64: 151–158.
 96. Adepu R, Ari SM (2010) Influence of structured patient education on therapeutic outcomes in diabetes and hypertensive patients. *Asian Journal of Pharmaceutical and Clinical Research* 3: 174–178.
 97. Gabriel AVC, Gabriel Aguc, Violato Cvuc (2010) Knowledge of and attitudes towards depression and adherence to treatment: The Antidepressant Adherence Scale (AAS). *Journal of Affective Disorders* Vol126(3), Nov 2010, 388–394.
 98. Garay-Sevilla ME, Porras JS, Malacara JM (2011) Coping strategies and adherence to treatment in patients with type 2 diabetes mellitus. *Rev Invest Clin* 63: 155–161.
 99. Garcia Vega OA, Buendia Rodriguez JA (2010) Beliefs about antihypertensive medications in primary care patients: Validation of beliefs about medicines questionnaire (BMQ) in Colombia. *Value in Health* 3: A177.
 100. McCann RM, Jackson AJ, Stevenson M, Dempster M, McElroy JC, et al. (2012) Help needed in medication self-management for people with visual impairment: case-control study. *Br J Gen Pract* 62: e530–537.
 101. McHorney CA, Gadkari AS (2010) Individual patients hold different beliefs to prescription medications to which they persist vs nonpersist and persist vs nonfill. *Patient Prefer Adherence* 4: 187–195.
 102. Quintero MA, Quintero Mamjec (2010) Dimensions of treatment adherence among Colombian women living with HIV/AIDS: A social perspective. *Revista Latinoamericana de Psicología* 42(2).
 103. Anuradha S, Joshi A, Negi M, Nischal N, Rajeshwari K, et al. (2012) Factors Influencing Adherence to ART: New Insights from a Center Providing Free ART under the National Program in Delhi, India. *J Int Assoc Physicians AIDS Care (Chic)*.
 104. Armour CL, Lemay K, Saini B, Reddel HK, Bosnic-Anticevich SZ, et al. (2011) Using the community pharmacy to identify patients at risk of poor asthma control and factors which contribute to this poor control. *J Asthma* 48: 914–922.
 105. de Guzman AB, Guevara KIJ, Guiang FJB, Gutierrez ALI, Habaluyas AS, et al. (2013) Developing a Model of Medication Adherence among Filipino Elderly. *Educational Gerontology* 39: 298–313.
 106. Benner JS, Nichol MB, Rovner ES, Jumadilova Z, Alvir J, et al. (2010) Patient-reported reasons for discontinuing overactive bladder medication. *BJU Int* 105: 1276–1282.
 107. Bermingham M, Hayden J, Dawkins I, Miwa S, Gibson D, et al. (2011) Prospective analysis of LDL-C goal achievement and self-reported medication adherence among statin users in primary care. *Clin Ther* 33: 1180–1189.
 108. Brandt S, Dickinson B (2013) Time and risk preferences and the use of asthma controller medication. *Pediatrics* 131: e1204–1210.
 109. Brask-Lindemann D, Cadarette SM, Eskildsen P, Abrahamsen B (2011) Osteoporosis pharmacotherapy following bone densitometry: importance of patient beliefs and understanding of DXA results. *Osteoporos Int* 22: 1493–1501.
 110. Broadbent E, Donkin L, Stroh JC (2011) Illness and treatment perceptions are associated with adherence to medications, diet, and exercise in diabetic patients. *Diabetes Care* 34: 338–340.
 111. Brubaker L, Fanning K, Goldberg EL, Benner JS, Trocio JN, et al. (2010) Predictors of discontinuing overactive bladder medications. *BJU Int* 105: 1283–1290.
 112. Cottrell WN, Denaro CP, Emmerton L (2013) Exploring beliefs about heart failure treatment in adherent and nonadherent patients: use of the repertory grid technique. *Patient Prefer Adherence* 7: 141–150.

113. Crowley MJ, Grubber JM, Olsen MK, Bosworth HB (2013) Factors associated with non-adherence to three hypertension self-management behaviors: preliminary data for a new instrument. *J Gen Intern Med* 28: 99–106.
114. Davis DP, Jandrisevits MD, Iles S, Weber TR, Gallo LC (2012) Demographic, socioeconomic, and psychological factors related to medication non-adherence among emergency department patients. *J Emerg Med* 43: 773–785.
115. Ferreira C, Gay M, Regnier-Aeberhard F, Bricaire F (2010) Representation of illness and of treatment side effects as determinants of adherence to treatment of HIV patients. *Annales Medico-Psychologiques* 168: 25–33.
116. Foster JM, Smith L, Bosnic-Anticevich SZ, Usherwood T, Sawyer SM, et al. (2012) Identifying patient-specific beliefs and behaviours for conversations about adherence in asthma. *Intern Med J* 42: e136–144.
117. Garvie PA, Flynn PM, Belzer M, Britto P, Hu C, et al. (2011) Psychological factors, beliefs about medication, and adherence of youth with human immunodeficiency virus in a multisite directly observed therapy pilot study. *J Adolesc Health* 48: 637–640.
118. Gerber BS, Cano AI, Caceres ML, Smith DE, Wilken LA, et al. (2010) A pharmacist and health promoter team to improve medication adherence among Latinos with diabetes. *Ann Pharmacother* 44: 70–79.
119. Jarab AS, Alqudah SG, Khdour M, Shamsain M, Mukattash TL (2012) Impact of pharmaceutical care on health outcomes in patients with COPD. *Int J Clin Pharm* 34: 53–62.
120. Joseph HA, Flores SA, Parsons JT, Purcell DW (2010) Beliefs about transmission risk and vulnerability, treatment adherence, and sexual risk behavior among a sample of HIV-positive men who have sex with men. *AIDS Care* 22: 29–39.
121. Kalichman SC, Eaton L, Cherry C (2010) ‘There is no proof that HIV causes AIDS’: AIDS denialism beliefs among people living with HIV/AIDS. *Journal of Behavioral Medicine* 33: 432–440.
122. Kalichman SC, Amaral CM, White D, Swetsze C, Kalichman MO, et al. (2012) Alcohol and adherence to antiretroviral medications: interactive toxicity beliefs among people living with HIV. *J Assoc Nurses AIDS Care* 23: 511–520.
123. Kalichman SC, Grebler T, Amaral CM, McNeirey M, White D, et al. (2013) Intentional non-adherence to medications among HIV positive alcohol drinkers: prospective study of interactive toxicity beliefs. *J Gen Intern Med* 28: 399–405.
124. Markotic F, Cerni Obrdaj E, Zalihic A, Pehar R, Hadziosmanovic Z, et al. (2013) Adherence to pharmacological treatment of chronic nonmalignant pain in individuals aged 65 and older. *Pain Med* 14: 247–256.
125. Natarajan N, Putnam W, Van Aarsen K, Beverley Lawson K, Burge F (2013) Adherence to antihypertensive medications among family practice patients with diabetes mellitus and hypertension. *Can Fam Physician* 59: e93–e100.
126. Ng CH, Smith DJ, King J, Ong S, Schweitzer I (2012) Medication attitudes and beliefs in patients with psychotic and affective disorders on maintenance treatment. *Hum Psychopharmacol* 27: 57–62.
127. Nordmann JP, Baudouin C, Renard JP, Denis P, Regnault A, et al. (2010) Identification of noncompliant glaucoma patients using Bayesian networks and the Eye-Drop Satisfaction Questionnaire. *Clin Ophthalmol* 4: 1489–1496.
128. Petrie KJ, Perry K, Broadbent E, Weinman J (2012) A text message programme designed to modify patients’ illness and treatment beliefs improves self-reported adherence to asthma preventer medication. *Br J Health Psychol* 17: 74–84.
129. Peyrot M, Barnett AH, Meneghini LF, Schumm-Draeger PM (2012) Factors associated with injection omission/non-adherence in the Global Attitudes of Patients and Physicians in Insulin Therapy study. *Diabetes Obes Metab* 9999.
130. Piette JD, Heisler M, Harand A, Juip M (2010) Beliefs about prescription medications among patients with diabetes: variation across racial groups and influences on cost-related medication underuse. *J Health Care Poor Underserved* 21: 349–361.
131. Piette JD, Beard A, Rosland AM, McHorney CA (2011) Beliefs that influence cost-related medication non-adherence among the “haves” and “have nots” with chronic diseases. *Patient Prefer Adherence* 5: 389–396.
132. Powers BJ, Danus S, Grubber JM, Olsen MK, Oddone EZ, et al. (2011) The effectiveness of personalized coronary heart disease and stroke risk communication. *Am Heart J* 161: 673–680.
133. Saks EK, Wiebe DJ, Cory LA, Sammel MD, Arya LA (2012) Beliefs about medications as a predictor of treatment adherence in women with urinary incontinence. *J Womens Health (Larchmt)* 21: 440–446.
134. Shams MEE, Barakat EAME (2010) Measuring the rate of therapeutic adherence among outpatients with T2DM in Egypt. *Saudi Pharmaceutical Journal* 18: 225–232.
135. van Geffen EC, Heerdink ER, Hugtenburg JG, Siero FW, Egberts AC, et al. (2010) Patients’ perceptions and illness severity at start of antidepressant treatment in general practice. *Int J Pharm Pract* 18: 217–225.
136. Wilke T, Muller S, Morisky DE (2011) Toward identifying the causes and combinations of causes increasing the risks of nonadherence to medical regimens: combined results of two German self-report surveys. *Value Health* 14: 1092–1100.
137. Zarani F, Besharat MA, Sadeghian S, Sarami G (2010) The effectiveness of the information-motivation-behavioral skills model in promoting adherence in CABG patients. *Journal of Health Psychology* 15: 828–837.
138. Zeber JE, Miller AL, Copeland LA, McCarthy JF, Zivin K, et al. (2011) Medication adherence, ethnicity, and the influence of multiple psychosocial and financial barriers. *Adm Policy Ment Health* 38: 86–95.
139. Mardby A-C, Akerlind I, Jorgensen T (2007) Beliefs about medicines and self-reported adherence among pharmacy clients. *Patient Education & Counseling* 69: 158–164.
140. Webb DG, Horne R, Pinching AJ (2001) Treatment-related empowerment: preliminary evaluation of a new measure in patients with advanced HIV disease. *International Journal of STD & AIDS* 12: 103–107.
141. Higgins N, Livingstone G, Katona C (2004) Concordance therapy: an intervention to help older people take antidepressants. *Journal of Affective Disorders* 81: 287–291.
142. Clifford S, Barber N, Elliott R, Hartley E, Horne R (2006) Patient-centred advice is effective in improving adherence to medicines. *Pharmacy World & Science* 28: 165–170.
143. Theunissen NC, de Ridder DT, Bensing JM, Rutten GE (2003) Manipulation of patient-provider interaction: discussing illness representations or action plans concerning adherence. *Patient Education and Counselling* 51: 247–258.
144. Bekker HL, Gough D, Williams M (2003) Attendance choices about the Influenza Immunization Programme: evidence for targeting patients’ beliefs. *Psychology, Health and Medicine* 8: 279–288.
145. Lam F, Stevenson FA, Britten N, Stell IM (2001) Adherence to antibiotics prescribed in an accident and emergency department: the influence of consultation factors. *European Journal of Emergency Medicine* 8: 181–188.
146. Conn KM, Halterman JS, Fisher SG, Yoos HL, Chin NP, et al. (2005) Parental beliefs about medications and medication adherence among urban children with asthma. *Ambulatory Pediatrics* 5: 306–310.
147. Bane C, Hughes CM, McElroy JC (2006) The impact of depressive symptoms and psychosocial factors on medication adherence in cardiovascular disease. *Patient Education & Counseling* 60: 187–193.
148. Beck EM, Vögelin R, Wirtz M, Cavelti M, Kvrgric S, et al. (2012) Do patients with schizophrenia distinguish between attitudes toward antipsychotic medication and pharmacotherapy in general? validation of the beliefs about medication questionnaire. *Journal of Nervous & Mental Disease* 200: 33–43.
149. Bender BG, Apter A, Bogen DK, Dickinson P, Fisher L, et al. (2010) Test of an interactive voice response intervention to improve adherence to controller medications in adults with asthma. *J Am Board Fam Med* 23: 159–165.
150. Daleboudt GM, Broadbent E, McQueen F, Kaptein AA (2011) Intentional and unintentional treatment nonadherence in patients with systemic lupus erythematosus. *Arthritis Care Res (Hoboken)* 63: 342–350.
151. Gray TA, Fenerty C, Harper R, Spencer AF, Campbell M, et al. (2012) Individualised patient care as an adjunct to standard care for promoting adherence to ocular hypotensive therapy: an exploratory randomised controlled trial. *Eye (Lond)* 26: 407–417.
152. Lennerling A, Forsberg A (2012) Self-reported non-adherence and beliefs about medication in a Swedish kidney transplant population. *Open Nurs J* 6: 41–46.
153. Mann DM, Poneman D, Montori VM, Arciniega J, McGinn T (2010) The Statin Choice decision aid in primary care: a randomized trial. *Patient Educ Couns* 80: 138–140.
154. Montgomery AT, Kalvemark Sporrang S, Manap N, Tully MP, Lindblad AK (2010) Receiving a pharmaceutical care service compared to receiving standard pharmacy service in Sweden-How do patients differ with regard to perceptions of medicine use and the pharmacy encounter? *Research in Social and Administrative Pharmacy* 6: 185–195.
155. Moshkovska T, Stone MA, Smith RM, Bankart J, Baker R, et al. (2011) Impact of a tailored patient preference intervention in adherence to 5-aminosalicylic acid medication in ulcerative colitis: results from an exploratory randomized controlled trial. *Inflamm Bowel Dis* 17: 1874–1881.
156. Roy A, Lurslurchachai L, Halm EA, Li XM, Leventhal H, et al. (2010) Use of herbal remedies and adherence to inhaled corticosteroids among inner-city asthmatic patients. *Ann Allergy Asthma Immunol* 104: 132–138.
157. Shiyabola OO, Farris KB, Chrischilles E (2012) Concern beliefs in medications: Changes over time and medication use factors related to a change in beliefs. *Res Social Adm Pharm* 9(4): 446–457.
158. van den Bemt BJ, den Broeder AA, van den Hoogen FH, Benraad B, Hekster YA, et al. (2011) Making the rheumatologist aware of patients’ non-adherence does not improve medication adherence in patients with rheumatoid arthritis. *Scand J Rheumatol* 40: 192–196.
159. Ross S, Walker A, MacLeod MJ (2004) Patient compliance in hypertension: role of illness perceptions and treatment beliefs. *Journal of Human Hypertension* 18: 607–613.
160. Brown JL, Littlewood RA, Vanable PA (2013) Social-cognitive correlates of antiretroviral therapy adherence among HIV-infected individuals receiving infectious disease care in a medium-sized northeastern US city. *AIDS Care* 25(9): 1149–1158.
161. Garfield S, Clifford S, Eliasson L, Barber N, Willson A (2011) Suitability of measures of self-reported medication adherence for routine clinical use: A systematic review. *BMC Medical Research Methodology* 11: 149.
162. Hofstede G (2001) *Culture’s Consequences, Comparing Values, Behaviors, Institutions, and Organizations Across Nations*. Thousand Oaks CA: Sage Publications.
163. Leventhal H, Brissette I, Leventhal E (2003) The common-sense model of self-regulation of health and illness. In: Cameron LD, Leventhal H, editors. *The self-regulation of health and illness behaviour*. New York: Routledge. p.42.
164. Kleinman A (1986) Illness meanings and illness behaviour. In: McHugh S, Vallis TM, editors. *Illness behavior: A multidisciplinary model*. New York: Plenum Press. 149–160.

165. Halm EA, Mora P, Leventhal H (2006) No Symptoms, No Asthma*The Acute Episodic Disease Belief Is Associated With Poor Self-Management Among Inner-City Adults With Persistent Asthma. *CHEST Journal* 129: 573–580.
166. Horne R, Weinman J (2002) Self regulation and self management in asthma: Exploring the role of illness perceptions and treatment beliefs in explaining non-adherence to preventer medication. *Psychology and Health* 17: 17–32.
167. Horne R, Parham R, Driscoll R, Robinson A (2009) Patients' attitudes to medicines and adherence to maintenance treatment in inflammatory bowel disease. *Inflammatory Bowel Diseases* 15: 837–844.
168. Calnan M, Montaner D, Horne R (2005) How acceptable are innovative health-care technologies? A survey of public beliefs and attitudes in England and Wales. *Social Science & Medicine* 60: 1937–1948.
169. Bowskill R, Clatworthy J, Parham R, Rank T, Horne R (2007) Patients' perceptions of information received about medication prescribed for bipolar disorder: Implications for informed choice. *Journal of Affective Disorders* 100: 253–257.
170. Elliott R, Barber N, Clifford S, Horne R, Hartley E (2008) The cost effectiveness of a telephone-based pharmacy advisory service to improve adherence to newly prescribed medicines. *Pharmacy World & Science* 30: 17–23.
171. Aakre JM, Medoff DR, Dixon LB, Kreyenbuhl JA (2012) Beliefs about antipsychotic versus hypoglycemic medications among individuals with serious mental illness and type 2 diabetes. *Patient Prefer Adherence* 6: 389–394.
172. Afkaseir A (2012) Role of illness and medication perceptions on adherence to medication in a group of Iranian patients with type 2 diabetes. *J Diabetes* 4: 243–247.
173. Aikens JE, Piette JD (2009) Diabetic Patients' Medication Underuse, Illness Outcomes, and Beliefs About Antihyperglycemic and Antihypertensive Treatments. *Diabetes Care* 32: 19–24.
174. Aikens JE, Klinkman MS (2012) Changes in patients' beliefs about their antidepressant during the acute phase of depression treatment. *Gen Hosp Psychiatry* 34: 221–226.
175. Barnes L, Moss-Morris R, Kaufusi M (2004) Illness beliefs and adherence in diabetes mellitus: a comparison between Tongan and European patients. *New Zealand Medical Journal* 117: 743.
176. Beck EM, Cavelti M, Kvirgic S, Kleim B, Vauth R (2011) Are we addressing the 'right stuff' to enhance adherence in schizophrenia? Understanding the role of insight and attitudes towards medication. *Schizophr Res* 132: 42–49.
177. Berglund E, Lyts P, Westerling R (2013) Adherence to and beliefs in lipid-lowering medical treatments: a structural equation modeling approach including the necessity-concern framework. *Patient Educ Couns* 91: 105–112.
178. Bhattacharya D, Easthall C, Willoughby KA, Small M, Watson S (2012) Capecitabine non-adherence: exploration of magnitude, nature and contributing factors. *J Oncol Pharm Pract* 18: 333–342.
179. Brown C, Battista DR, Bruhlman R, Sereika SS, Thase ME, et al. (2005) Beliefs about antidepressant medications in primary care patients: relationship to self-reported adherence. *Medical Care* 43: 1203–1207.
180. Butler JA, Peveler RC, Roderick P, Smith PWF, Horne R, et al. (2004) Modifiable risk factors for non-adherence to immunosuppressants in renal transplant recipients: A cross sectional study. *Nephrology Dialysis Transplantation* 19: 3144–3149.
181. Chisholm-Burns M, Pinsky B, Parker G, Johnson P, Arcona S, et al. (2012) Factors related to immunosuppressant medication adherence in renal transplant recipients. *Clin Transplant* 26: 706–713.
182. Cooper V, Moyle GJ, Fisher M, Reilly G, Ewan J, et al. (2011) Beliefs about antiretroviral therapy, treatment adherence and quality of life in a 48-week randomised study of continuation of zidovudine/lamivudine or switch to tenofovir DF/emtricitabine, each with efavirenz. *AIDS Care* 23: 705–713.
183. de Boer-van der Kolk IM, Sprangers MAG, Ende Mvd, Schreij G, Wolf Fd, et al. (2008) Lower Perceived Necessity of HAART Predicts Lower Treatment Adherence and Worse Virological Response in the ATHENA Cohort. *JAIDS Journal of Acquired Immune Deficiency Syndromes* 49: 460–462.
184. De Las Cuevas C, Penate W, Sanz EJ (2013) Psychiatric outpatients' self-reported adherence versus psychiatrists' impressions on adherence in affective disorders. *Hum Psychopharmacol* 28: 142–150.
185. De Smedt RH, Jaarsma T, Ranchor AV, van der Meer K, Groenier KH, et al. (2012) Coping with adverse drug events in patients with heart failure: Exploring the role of medication beliefs and perceptions. *Psychol Health* 27: 570–587.
186. Ediger JP, Walker JR, Graff L, Lix L, Clara I, et al. (2007) Predictors of medication adherence in inflammatory bowel disease. *American Journal of Gastroenterology* 102: 1417–1426.
187. Emilsson M, Berndtsson I, Lotvall J, Millqvist E, Lundgren J, et al. (2011) The influence of personality traits and beliefs about medicines on adherence to asthma treatment. *Prim Care Respir J* 20: 141–147.
188. Fawzi W, Abdel Mohsen MY, Hashem AH, Moussa S, Coker E, et al. (2012) Beliefs about medications predict adherence to antidepressants in older adults. *Int Psychogeriatr* 24: 159–169.
189. Foo RC, Lamoureux EL, Wong RC, Ho SW, Chiang PP, et al. (2012) Acceptance, attitudes, and beliefs of Singaporean Chinese toward an ocular implant for glaucoma drug delivery. *Invest Ophthalmol Vis Sci* 53: 8240–8245.
190. Gauchet A, Tarquinio C, Fischer G (2007) Psychosocial predictors of medication adherence among persons living with HIV. *International Journal of Behavioral Medicine* 14: 141–150.
191. Gatti ME, Jacobson KL, Gazmararian JA, Schmotzer B, Kripalani S (2009) Relationships between beliefs about medications and adherence. *American Journal of Health-System Pharmacy* 66: 657–664.
192. George J, Shalansky SJ (2007) Predictors of refill non-adherence in patients with heart failure. *British Journal of Clinical Pharmacology* 63: 488–493.
193. Griva K, Davenport A, Harrison M, Newman SP (2012) Non-adherence to immunosuppressive medications in kidney transplantation: intent vs. forgetfulness and clinical markers of medication intake. *Ann Behav Med* 44: 85–93.
194. Grunfeld EA, Hunter MS, Sikka P, Mittal S (2005) Adherence beliefs among breast cancer patients taking tamoxifen. *Patient Education & Counseling* 59: 97–102.
195. Hedenrud T, Jonsson P, Linde M (2008) Beliefs about medicines and adherence among Swedish migraineurs. *Annals of Pharmacotherapy* 42: 39–45.
196. Horne R, Sumner S, Jubraj B, Weinman J, Frost S (2001) Haemodialysis patients' beliefs about treatment: Implications for adherence to medication and fluid-diet restrictions. *International Journal of Pharmacy Practice* 9: 169–175.
197. Horne R, Buick D, Fisher M, Leake H, Cooper V, et al. (2004) Doubts about necessity and concerns about adverse effects: Identifying the types of beliefs that are associated with non-adherence to HAART. *International Journal of STD and AIDS* 15: 38–44.
198. Horne R, Cooper V, Gellaity G, Date HL, Fisher M (2007) Patients' Perceptions of Highly Active Antiretroviral Therapy in Relation to Treatment Uptake and Adherence: The Utility of the Necessity-Concerns Framework. *JAIDS* 45: 334–341.
199. Hou R, Cleak V, Peveler R (2010) Do treatment and illness beliefs influence adherence to medication in patients with bipolar affective disorder? A preliminary cross-sectional study. *Eur Psychiatry* 25: 216–219.
200. Hunot VM, Horne R, Leese MN, Churchill RC (2007) A Cohort Study of Adherence to Antidepressants in Primary Care: The Influence of Antidepressant Concerns and Treatment Preferences. The Primary Care Companion to The Journal of Clinical Psychiatry 9: 91–99.
201. Iihara N, Suzuki K, Kurosaki Y, Morita S, Hori K (2010) Factorial invariance of a questionnaire assessing medication beliefs in Japanese non-adherent groups. *Pharm World Sci* 32: 432–439.
202. Jónsdóttir H, Friis S, Horne R, Pettersen KI, Reikvam Å, et al. (2009) Beliefs about medications: measurement and relationship to adherence in patients with severe mental disorders. *Acta Psychiatrica Scandinavica* 119: 78–84.
203. Kemp S, Feely M, Hay A, Wild H, Cooper C (2007) Psychological factors and use of antiepileptic drugs: pilot work using an objective measure of adherence. *Psychology, Health & Medicine* 12: 107–113.
204. Khanderia U, Townsend KA, Erickson SR, Vlasnik J, Prager RL, et al. (2008) Medication adherence following coronary artery bypass graft surgery: assessment of beliefs and attitudes. *Annals of Pharmacotherapy* 42: 192–199.
205. Kressin NR, Orner MB, Manze M, Glickman ME, Berlowitz D (2010) Understanding contributors to racial disparities in blood pressure control. *Circ Cardiovasc Qual Outcomes* 3: 173–180.
206. Kronish I, Diefenbach M, Edmondson D, Phillips LA, Fei K, et al. (2013) Key Barriers to Medication Adherence in Survivors of Strokes and Transient Ischemic Attacks. *Journal of General Internal Medicine* 28: 675–682.
207. Kung M, Koschwanez HE, Painter L, Honeyman V, Broadbent E (2012) Immunosuppressant nonadherence in heart, liver, and lung transplant patients: associations with medication beliefs and illness perceptions. *Transplantation* 93: 958–963.
208. Maguire LK, Hughes CM, McElnay JC (2008) Exploring the impact of depressive symptoms and medication beliefs on medication adherence in hypertension—A primary care study. *Patient Education and Counseling* 73: 371–376.
209. Mahler C, Hermann K, Horne R, Jank S, Haefeli WE, et al. (2012) Patients' beliefs about medicines in a primary care setting in Germany. *J Eval Clin Pract* 18: 409–413.
210. Menckeborg TT, Bouvy ML, Bracke M, Kaptein AA, Leufkens HG, et al. (2008) Beliefs about medicines predict refill adherence to inhaled corticosteroids. *Journal of Psychosomatic Research* 64: 47–54.
211. Moshkovska T, Stone M, Baker R, Smith R, Clatworthy J, et al. (2009) An investigation of medication adherence to 5-aminosalicylic acid therapy in patients with ulcerative colitis. *Gut* 58: A43–A44.
212. Nakhutina L, Gonzalez JS, Margolis SA, Spada A, Grant A (2011) Adherence to antiepileptic drugs and beliefs about medication among predominantly ethnic minority patients with epilepsy. *Epilepsy Behav* 22: 584–586.
213. Neame R, Hammond A (2005) Beliefs about medications: a questionnaire survey of people with rheumatoid arthritis.[see comment]. *Rheumatology* 44: 762–767.
214. Nicklas LB, Dunbar M, Wild M (2010) Adherence to pharmacological treatment of non-malignant chronic pain: the role of illness perceptions and medication beliefs. *Psychol Health* 25: 601–615.
215. O'Carroll RE, McGregor LM, Swanson V, Masterton G, Hayes PC (2006) Adherence to medication after liver transplantation in Scotland: a pilot study. *Liver Transplantation* 12: 1862–1868.
216. Percival M, Cottrell WN, Jayasinghe R (2012) Exploring the beliefs of heart failure patients towards their heart failure medicines and self care activities. *Int J Clin Pharm* 34: 618–625.

217. Peters KF, Home R, Kong F, Francomano CA, Biesecker BB (2001) Living with Marfan syndrome II. Medication adherence and physical activity modification. *Clinical Genetics* 60: 283–292.
218. Phatak HM, Thomas J 3rd (2006) Relationships between beliefs about medications and nonadherence to prescribed chronic medications. *Annals of Pharmacotherapy* 40: 1737–1742.
219. Rees G, Leong O, Crowston JG, Lamoureux EL (2010) Intentional and unintentional nonadherence to ocular hypotensive treatment in patients with glaucoma. *Ophthalmology* 117: 903–908.
220. Rees G, Chong XL, Cheung CY, Aung T, Friedman DS, et al. (2013) Beliefs and Adherence to Glaucoma Treatment: A Comparison of Patients From Diverse Cultures. *J Glaucoma*. doi: 10.1097/IJG.0b013e3182741f1c.
221. Reynolds K, Viswanathan HN, O'Malley CD, Muntner P, Harrison TN, et al. (2012) Psychometric properties of the Osteoporosis-specific Morisky Medication Adherence Scale in postmenopausal women with osteoporosis newly treated with bisphosphonates. *Ann Pharmacother* 46: 659–670.
222. Ruppert TM, Dobbels F, De Geest S (2012) Medication beliefs and antihypertensive adherence among older adults: a pilot study. *Geriatr Nurs* 33: 89–95.
223. Russell J, Kazantzis N (2008) Medication beliefs and adherence to antidepressants in primary care. *The New Zealand medical journal* 121: 14–20.
224. Schoenthaler AM, Schwartz BS, Wood C, Stewart WF (2012) Patient and physician factors associated with adherence to diabetes medications. *Diabetes Educ* 38: 397–408.
225. Schuz B, Marx C, Wurm S, Warner LM, Ziegelmann JP, et al. (2011) Medication beliefs predict medication adherence in older adults with multiple illnesses. *J Psychosom Res* 70: 179–187.
226. Shiyabola OO, Nelson J (2011) Illness perceptions, beliefs in medicine and medication non-adherence among South Dakota minority women with diabetes: a pilot study. *S D Med* 64: 365–368.
227. Sirey JA, Greenfield A, Weinberger MI, Bruce ML (2013) Medication beliefs and self-reported adherence among community-dwelling older adults. *Clin Ther* 35: 153–160.
228. Sofianou A, Martynenko M, Wolf MS, Wisnivesky JP, Krauskopf K, et al. (2013) Asthma beliefs are associated with medication adherence in older asthmatics. *J Gen Intern Med* 28: 67–73.
229. Tibaldi G, Clatworthy J, Torchio E, Argentero P, Munizza C, et al. (2009) The utility of the Necessity–Concerns Framework in explaining treatment non-adherence in four chronic illness groups in Italy. *Chronic Illness* 5: 129–133.
230. Treharne GJ, Lyons AC, Kitas GD (2004) Medication adherence in rheumatoid arthritis: effects of psychosocial factors *Psychology, Health and Medicine* 13: 337–349.
231. Uusküla A, Laisaar K-T, Raag M, Šmidt J, Semjonova S, et al. (2012) Antiretroviral therapy (ART) adherence and correlates to nonadherence among people on ART in Estonia. *AIDS Care* 24: 1470–1479.
232. van den Bemt BJF, van den Hoogen FHJ, Benraad B, Hekster YA, van Riel PLCM, et al. (2009) Adherence Rates and Associations with Nonadherence in Patients with Rheumatoid Arthritis Using Disease Modifying Antirheumatic Drugs. *The Journal of Rheumatology* 36: 2164–2170.
233. Voils CI, Maciejewski ML, Hoyle RH, Reeve BB, Gallagher P, et al. (2012) Initial validation of a self-report measure of the extent of and reasons for medication nonadherence. *Med Care* 50: 1013–1019.
234. Wileman V, Chilcot J, Norton S, Hughes L, Wellsted D, et al. (2011) Choosing not to take phosphate binders: the role of dialysis patients' medication beliefs. *Nephron Clin Pract* 119: c205–213.
235. Wong M, Mulherin D (2007) The influence of medication beliefs and other psychosocial factors on early discontinuation of disease-modifying anti-rheumatic drugs. *Musculoskeletal Care* 5: 148–159.
236. Yu ZL, Yeoh LY, Seow YY, Luo XC, Griva K (2012) Evaluation of adherence and depression among patients on peritoneal dialysis. *Singapore Med J* 53: 474–480.
237. Zerah L, Arena C, Morin AS, Blanchon T, Cabane J, et al. (2012) [Patients' beliefs about long-term glucocorticoid therapy and their association to treatment adherence]. *Rev Med Interne* 33: 300–304.