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REVIEW

The impact of pharmacist interventions on osteoporosis management: a systematic review

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Abstract
Summary We completed a systematic review of the literature to examine the impact of pharmacist interventions in improving osteoporosis management. Results from randomized controlled trials suggest that pharmacist interventions may improve bone mineral density testing and calcium intake among patients at high risk for osteoporosis.
Introduction Pharmacists play a key role in many healthcare systems by helping patients manage chronic diseases. We completed a systematic review of the literature to identify randomized controlled trials (RCTs) that have examined the impact of pharmacy interventions in narrowing two gaps in osteoporosis management: identifying at-risk individuals and improving adherence to therapy.
Methods We searched the electronic databases of EMBASE, HealthStar, *International Pharmaceutical Abstracts*, MEDLINE, and PubMed from database development to April 2010, examined grey literature, and completed manual searches of reference lists to identify English-language research that examined osteoporosis management interventions within pharmacy practice. Results from RCTs were abstracted and assessed for bias.
Results We identified 25 studies that examined pharmacist interventions in osteoporosis management: 16 cohort, 5 cross-sectional, 1 historical/ecological control, and 3 RCTs. RCT interventions included osteoporosis educational and counseling programs, screening by pharmacists based on risk factor assessment or bone mineral density testing, and physician contact or recommendations for patients to follow-up with a general practitioner. Results from the three RCTs suggest that pharmacist interventions may improve bone mineral density testing (targeted screening) and calcium intake among patients at high risk for osteoporosis. However, two of the three RCTs had high risk of bias, and no study examined the impact of pharmacist intervention on osteoporosis treatment adherence.
Conclusions Data support the potential role for pharmacists to help reduce gaps in osteoporosis management through improved identification of high-risk patients. More research is needed to examine pharmacist interventions on osteoporosis treatment adherence.

Keywords Osteoporosis · Outcome assessment · Pharmacists · Review · Systematic

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Introduction

Two gaps in osteoporosis management are well documented: (1) most patients at high risk for fracture are not identified for treatment, and (2) adherence to osteoporosis pharmacotherapy is suboptimal [1–3]. For example, post-fracture osteoporosis screening and treatment rates are below 20% in most settings [1, 4], and approximately half of the patients who start osteoporosis pharmacotherapy discontinue treatment within the first year of therapy [2, 3]. In theory, pharmacists may play a role in narrowing gaps in osteoporosis diagnosis and treatment adherence. First, pharmacists may help identify high-risk patients, such as those on chronic glucocorticoid therapy who can then be targeted for bone mineral density (BMD) testing and treatment initiation. Second, pharmacists can provide counseling and educate patients on medication use, fall prevention, and the importance of calcium, vitamin D, exercise, and adherence to therapy. A recent review identified that non-drug interventions by healthcare professionals improved quality of life, treatment adherence, and calcium intake among community-dwelling postmenopausal women with osteoporosis; however, no study within the review examined pharmacist interventions [5]. We therefore completed a systematic review of the literature to identify all

articles that have examined the impact of pharmacist interventions in osteoporosis management. The purpose of our review was to use results from randomized controlled trials (RCTs) to determine if pharmacy interventions can help narrow two gaps in osteoporosis management: identifying at-risk individuals and improving adherence to therapy.

Methods

Data sources and study eligibility

The electronic databases EMBASE, HealthStar, *International Pharmaceutical Abstracts*, MEDLINE, and PubMed were searched from database development to April 2010 to identify all English language publications that examined pharmacist interventions in osteoporosis management. Search terms were adapted from a Cochrane Collaboration review [6] and selected upon consultation with a library scientist, Appendix Table 4. Any intervention that utilized a pharmacist to improve osteoporosis management was eligible. Manual searches of reference lists from eligible studies and a grey literature search were also completed [7, 8]. Our grey literature search targeted government, research institution, professional association, and osteoporosis foundation websites to try to capture research published as a report and not accessible through traditional research databases, Appendix Table 5. Abstracts, commentaries, letters, news articles, and review papers were excluded. Titles and abstracts were reviewed for relevance by two authors (MNE, AMB), and discrepancies were settled through consultation with a third author (SMC). All relevant publications were identified, yet only RCTs were eligible for detailed review. We therefore identified all papers that included a pharmacist in the context of osteoporosis management, yet focused on RCTs as these may provide the highest quality of evidence [8].

RCT data abstraction

Study characteristics including research design, setting, pharmacist training, patient inclusion criteria, patient recruitment, intervention details, and outcomes were abstracted by two authors (MNE, AMB) and confirmed by a third author (SMC). Since the ultimate goal of identifying high-risk patients is treatment to reduce fracture risk, our a priori focus was on process of care outcomes related to improved identification of at-risk individuals (e.g., BMD testing and physician follow-up) and osteoporosis treatment initiation. We had intended to examine the impact of pharmacist interventions on osteoporosis treatment adherence; however, no relevant study was identified. After the identification of relevant literature, we decided to summarize information concerning improvements in calcium and vitamin D intake or supplementation.

Qualitative assessment of risk of bias

We qualitatively examined the threats to internal validity for each trial based on risk for allocation bias, attrition bias, detection bias, and performance bias [8, 9]. Following recent guidelines to improve terminology in non-experimental research [10], we grouped these four potential biases into two types: (1) selection bias, related to allocation and attrition, and (2) information bias, related to detection and performance. Allocation bias occurs when randomization fails such that comparison groups differ on important prognostic variables. Attrition bias occurs when patients who continue to be followed are systematically different from those who are lost to follow-up in ways that impact outcomes. Detection and performance biases are classified as different types of information bias—biases that occur when there are systematic differences in the completeness or accuracy of data that lead to differential misclassification of patient characteristics, exposure, or outcomes [10]. Detection bias results from differential outcome assessment between comparison groups, and performance bias results from unequal provision of care between comparison groups other than differences related to the main intervention [9]. We then classified the level of risk of bias based on whether there was little evidence that the bias would impact study results (low) or if some evidence suggested that the bias may have impacted study results (high). We did not use a more fine assessment to identify medium risk of bias.

Results

Of the 611 unique English language publications identified from the database searches, 118 were pulled for detailed review and one additional publication [11] was found from the manual search of reference lists, Fig. 1. No grey literature was identified. Of the 119 publications reviewed, 25 examined pharmacist interventions in osteoporosis management: 16 cohort [12–27], five cross-sectional [28–32], one historical/ecological control [33], and three RCTs [34–36]. Of the three RCTs, two were cluster RCTs that involved the randomization of pharmacies/pharmacists rather than randomization of single patients [34, 35]. Characteristics of the three RCTs are summarized in Table 1, and potential biases are summarized in Table 2.

1. Cluster RCT in Australia

Crockett et al. completed a cluster RCT in New South Wales, Australia whereby all 86 community pharmacists in six suburb and six rural communities were invited to participate [34]. Of the pharmacists that were willing and had suitable space and staffing to participate, one pharmacist within each of the six suburban and six rural areas was randomly selected

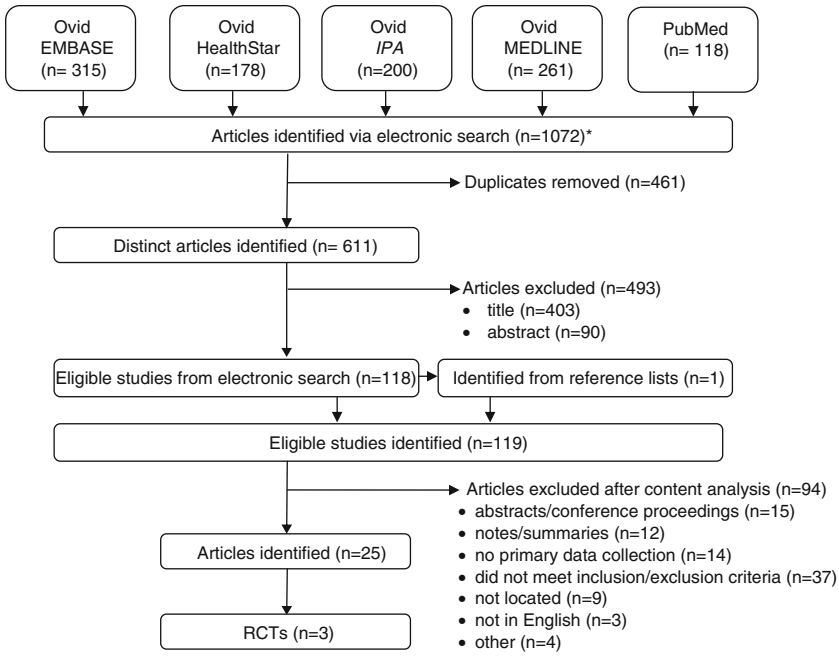

Fig. 1 Flow chart of literature search strategy. *IPA* International Pharmaceutical Abstracts. *no grey literature identified from our primary search (Appendix Table 5)

for participation. Each of the 12 randomly selected pharmacists was then randomized into one of two groups: (1) *non-BMD group*, pharmacists offered education, counseling, and risk assessment based on patient questionnaire responses only and (2) *BMD group*, pharmacists offered education, counseling, and risk assessment based on questionnaire responses and forearm BMD test results. The forearm BMD tests were performed by a radiographer using peripheral dual-energy X-ray absorptiometry (DXA). All 12 participating pharmacists were provided with an information package and invited to attend a 7-h training session or receive an on-site training visit. After pharmacist training, the chief research officer and project officer visited study sites to ensure adherence to protocol and service delivery consistency. Each pharmacist was asked to recruit 20 participants meeting eligibility criteria (Table 1). Participants deemed to be at medium or high risk based on questionnaire (non-BMD group) or questionnaire and BMD (BMD group) were advised to see a general practitioner. Outcomes were assessed by telephone follow-up at 3 and 6 months post-intervention. The outcomes of interest for our review included patient self-report of pharmacist recommendations (increase in calcium or vitamin D intake and need for follow-up with a general practitioner), and whether or not the patient followed through with baseline recommendations given by the pharmacist.

The internal validity of this trial is limited with high risk of bias across all four levels evaluated, Table 2. First, we note potential selection bias related to allocation: patients self-referred into the study and there was a significant difference in recruitment success between the rural non-BMD (n=43 of 60 target) and rural BMD (n=60 of 60 target) pharmacies; and attrition: although 87% of participants responded at 3 months, only 20 (10%) patients in total were contacted at 6 months [34]. In addition, the 6-month follow-up was targeted to those deemed at high risk at baseline, yet baseline risk assessment was differential between groups (performance bias). Finally, potential detection bias is high with outcomes based on patient self-report and the patient's ability to recall pharmacist recommendations. Despite limitations and documentation of little difference in study outcomes in terms of physician follow-up or calcium/vitamin D intake (Table 3), the study found significantly better patient satisfaction after 3 months of follow-up among those provided with the intervention that included forearm BMD testing (90% satisfied), compared to those with the educational intervention that did not include BMD measurement (67% satisfied) [34].

2. Cluster RCT in USA

McDonough et al. completed a cluster RCT of 15 community pharmacies (eight intervention, seven control) in Iowa, USA [35]. These pharmacies were part of a specialized provider network consisting of pharmacists with previous training and/or certification in drug therapy monitoring and research participation. All pharmacists in the participating pharmacies received approximately 4 h of training related to glucocorticoid-induced osteoporosis and were provided with a package of articles for independent study. Pharmacists within each pharmacy then used dispensing records to identify and mail invitation letters to eligible patients (aged ≥18 years with the equivalent of 7.5 mg or more of prednisone for ≥6 months). Pharmacies in the control group provided "usual and customary care" to participants. Intervention group pharmacies provided

Table 1 Characteristics of randomized controlled trials of osteoporosis interventions in pharmacy practice

Study, Design, Setting	Inclusion Criteria	Training	Recruitment	Groups	*n*	Description
Crockett et al. [34] Cluster RCT[a], Australia (New South Wales) 12 community pharmacies	• Women >40 years • Men >50 years • No BMD test in prior 2 years • No prior OP treatment	• 7-h training session • Information package • On-site visit to check protocol	• Ads in local newspaper • Notices in participating pharmacies • Participants called to book appointment	Non-BMD[a] (6 sites)	98 (84)[e]	• Pharmacist completed risk assessment using a questionnaire to categorize patients as: low, medium, or high risk • All counselled regarding lifestyle modifications • High and medium risk: encouraged to follow-up with general practitioner
				BMD[a] (6 sites)	119 (114)[e]	• Same as above; however, forearm DXA also used to classify risk (low, T>−1.0; medium, −1.0≥T>−2.5; or high, T≤−2.5)
McDonough et al. [35] Cluster RCT[b], United States (Eastern Iowa) 15 community pharmacies	• ≥18 years • Taking ≥7.5 mg glucocorticoid for ≥6 months	• 4-h classroom education • Packet of articles for independent study	• Patients identified from dispensing records and recruited by mail	Control (7 sites)	26 (19)[e]	• Usual care
				Intervention (8 sites)	70 (61)[e]	• Education and information pamphlet on risks of glucocorticoid-induced OP • Medication review (appropriateness of dose, regimen, potential interactions, non-adherence, and adverse effects); with problems discussed with patient and/or prescribing physician • Standardized physician communication mailed to prescribers (information about the program and patients enrolled)
Yuksel et al. 2010 [36] RCT[c], Canada (Alberta) 15 community pharmacies	• ≥65 years • 50–64 years with ≥1 major risk factor[d] • No BMD test in prior 2 years • No current OP treatment • English speaking	• Pharmacists trained by investigators	• Ads in local newspaper • Notices in participating pharmacies • Participants called to book appointment • Pharmacist identification in pharmacy	Control	133	• Usual care and print material from OP Canada

				Intervention	129	• 30-min appointment on clinic day:
						  • Print material from OP Canada
						  • Pamphlet designed by study investigators
						  • Pharmacist counseling (tailored OP education)
						  • Heel QUS measurement and interpretation
						  • Patients encouraged to follow-up with their primary care physician
						• Physicians provided with study details, QUS results, and information regarding patient eligibility for central BMD testing
						• Follow-up
						  • Telephone: 2 and 8 weeks
						  • Patients asked to return to pharmacy at 16 weeks

RCT randomized controlled trial (in cluster RCT, groups randomized by pharmacy), *BMD* bone mineral density, *DXA* dual-energy X-ray absorptiometry, *OP* osteoporosis, *QUS* quantitative ultrasound, *n* number of participants

[a] Of all pharmacists agreeing and eligible to participate, one was randomly selected from each of six suburban and six rural areas. These 12 pharmacists were then randomized into one of two groups with three suburban and three rural pharmacies in each of the two groups

[b] Pharmacies from a specialized provider network consisting of pharmacists with previous training and/or certification in drug therapy monitory and research participation

[c] Randomized by secure internet randomization services (sequence stratified by site with block size of 4)

[d] Major risk factor included: family history of osteoporosis, previous fracture, systemic glucocorticoids >3 months, or early menopause

[e] Sample size after exclusion of missing data or participants who did not complete the study

Table 2 Summary of potential risk of bias based on threats to internal validity

Study	Selection Bias		Information Bias	
	Allocation[a]	Attrition[b]	Performance[c]	Detection[d]
Crockett et al. [34]	High • Better recruitment success in BMD group in rural regions (n=60 vs. n=43) • Non-BMD group had larger proportion with history of low-trauma fracture (21% vs. 11%)	High • 3-month follow-up, 87% • 6-month follow-up, 10%; only "high-risk" followed	High • Definition of risk differed between groups • Group 1: questionnaire only • Group 2: questionnaire and forearm BMD results	High • Self-report assessment based on patient recall of pharmacist recommendations and whether or not they complied with the pharmacist's recommendations
McDonough et al. [35]	High • Significantly more participants in intervention vs. control (n=70 vs. n=26) • Intervention group at higher risk, e.g.: a. Female (74% vs. 58%) b. Fracture history (30% vs. 12%)	High • Follow-up: • 87% intervention • 73% control	Low • Little evidence that the "usual care" group differed outside the intervention • All participating pharmacists had training or certification in research participation	Low • Although outcomes are based on self-report, evidence suggests that self-report of DXA testing and bisphosphonate use is very good [49, 50]
Yuksel et al. [36]	Low • Intervention group had significantly more participants with family history of OP (47% vs. 34%) • However, analyses adjusted for age, sex, and family history of OP	Low • Attrition: n=26 (20%) in intervention and n=23 (17%) in control • However, all were accounted for in the analyses (intention to treat analysis)	Low • All participating pharmacists received training • Control ("usual care") group also given educational material, and thus, the effect may be larger than what was observed in the trial when compared to true "usual care"	Low • Self-report confirmed by DXA report from physician (test performed) and pharmacy records (prescription dispensed)

Low risk of bias means that there is little evidence that this type of bias impacted study results. High risk of bias means that some evidence indicates that this type of bias may have impacted study results

BMD bone mineral density group (peripheral DXA), *DXA* dual-energy X-ray absorptiometry, *OP* osteoporosis

[a] Allocation bias occurs when randomization fails such that comparison groups differ on important prognostic variables

[b] Attrition bias may occur if patients who continue to be followed are systematically different from those who are lost to follow-up in ways that effect outcomes

[c] Performance bias results from differences in the provision of care between comparison groups other than differences that relate to the main intervention

[d] Detection bias results from differential outcome assessment between comparison groups

patients with: an information pamphlet about glucocorticoid-induced osteoporosis, education, and drug therapy monitoring. In addition, each participant's prescribing physician was mailed a standardized communication explaining the program, their patient's inclusion and any therapeutic problems identified. Study outcomes were assessed by web survey completed in the participating pharmacies at 9 months post-intervention. The outcomes of interest included change from baseline in bisphosphonate treatment, calcium supplementation, and DXA testing.

Overall risk of bias in this trial is high based on allocation and attrition (selection bias). First, we note potential allocation bias with significantly fewer participants enrolled in the control group (n=26) compared to the intervention group (n=70), and participants in the intervention group had higher baseline fracture risk: 74% intervention vs. 58% control were female, and 30% intervention vs. 12% control had a prior fracture; and prior osteoporosis management: 52% intervention vs. 24% control had a DXA test, and 17% intervention vs. 0% control used bisphosphonates at baseline.

Table 3 Measured outcomes in randomized controlled studies of pharmacy interventions in osteoporosis management

Study	Follow-up details	Outcomes measured	Group 1		Group 2	
			n	%	*n*	%
			Non-BMD, *n*=84		BMD, *n*=114	
Crockett et al. [34]	3-month telephone follow-up (patient self-report)	Physician follow-up	2/7	28.6	3/22	13.6
		Increase in calcium intake	37/45	82.2	29/38	76.3
		Increase in vitamin D intake	18/21	85.7	4/7	57.1
			Control, *n*=19		Intervention, *n*=61	
McDonough et al. [35]	9-month[a] web survey in pharmacy (patient self-report)	DXA test	–	39.2	–	19.6*
		Bisphosphonate therapy	–	10.5	–	9.1
		Calcium supplementation	–	−6.9	–	17.1*
			Control, *n*=133		Intervention, *n*=129	
Yuksel et al. [36]	16 weeks, patient self-report in pharmacy (confirmed by DXA report and pharmacy dispensing records)	Primary outcome				
		DXA test or OP treatment	14	10.5	28	21.7*
		Secondary outcomes				
		DXA test	13	9.8	28	21.7*
		New osteoporosis treatment	3	2.3	6	4.7
		Additional patients meeting:				
		Calcium requirements	25	18.8	39	30.2*
		Vitamin D requirements	22	16.5	24	18.6

BMD bone mineral density group (peripheral DXA), *DXA* dual-energy X-ray absorptiometry, *OP* osteoporosis

*$p<0.05$

[a] Percent change reported (from baseline to 9 months), calculated based on numbers presented in the paper. At baseline: 24% control vs. 52% intervention had a DXA test, and 0% control vs. 17% intervention used bisphosphonates

Second, attrition bias is relevant with only 61 participants in the intervention group (87%) and 19 participants in the control group (73%) after exclusions based on missing data. Therefore, although this trial documented significant improvements in calcium intake from baseline in the intervention group (+17%) compared to the control group (−7%) [35], and smaller increase in DXA testing (+20% intervention vs. +39% control), it is possible that the differences result from selection bias introduced in the trial.

3. RCT in Canada

Yuksel et al. completed an RCT within 15 Save on Foods community pharmacies in Alberta, Canada [36]. Patients who met eligibility based on risk for osteoporosis (Table 1) and who signed informed consent were randomized using a secure internet randomization service into two groups: control or intervention. Participants in the intervention group received oral and written education about their risks for osteoporosis, had BMD measured by heel quantitative ultrasound (QUS), and were counseled regarding their risks for osteoporosis during a 30 minute session with the pharmacist. Intervention patients were also encouraged to follow-up with their primary care physician, and physicians were informed about their patient's study enrolment, QUS results, and eligibility for central DXA testing. Participants in the control group received usual care and print material from Osteoporosis Canada. The primary outcome was a composite of DXA test and/or new osteoporosis treatment initiation at 4 months post-intervention. Self-report of the primary outcome was confirmed by physician contact (copy of DXA report) and pharmacy dispensing records (initiation of new osteoporosis medication). Secondary outcomes included daily calcium and vitamin D intake.

Despite randomization, a larger proportion of patients in the intervention group reported a family history of osteoporosis (47% vs. 34%, $p=0.03$), and although not statistically significant, we note a larger proportion in the intervention group were white (66% vs. 56%) and were current smokers (17% vs. 9%) [36]. Nonetheless, authors appropriately adjusted for important baseline risk factors for osteoporosis in their analysis, including age, sex, and family history of osteoporosis. We therefore document low risk of bias related to allocation. Similarly, although 49 patients were lost to follow-up after allocation (26 intervention, 23 control), all were appropriately included in the analysis, minimizing potential attrition bias. We classify the risk of detection bias as low because self-report of the primary outcome was confirmed by physician contact and pharmacy dispensing records. Although we document low risk for performance

bias, we note that the effects of the intervention may be larger in comparison to usual care in the "real-world," since the trial provided the control (usual care) group with information from Osteoporosis Canada. Results from this robust trial found that the pharmacist intervention increased DXA testing (22% intervention, 10% control) and improved calcium intake (30% intervention, 19% control) at 4 months follow-up, Table 3.

Discussion

Pharmacists play a key role as drug experts in many healthcare systems. Over the last 20 years, the pharmacist's role in many settings has shifted in focus from drug dispensing to patient-centered pharmaceutical care [37, 38]. Pharmacist interventions such as patient counseling, education, medication management, and referrals to other healthcare professionals have led to significant improvements in blood glucose levels among diabetic patients, blood pressure levels among antihypertensive patients, and cholesterol levels among hyperlipidemic patients [39–41]. From our review, we found that compared to "usual care," a pharmacist intervention that included patient counseling, education, QUS, and physician contact increased central DXA testing and calcium intake among individuals at high risk for osteoporosis. Although not specifically identified within the studies included in our review, a recent RCT identified that DXA testing among women aged 45–54 years significantly increased the use of osteoporosis pharmacotherapy and supplementation with calcium and vitamin D [42]. Further research is needed to determine if pharmacy interventions may also improve osteoporosis treatment initiation.

Result from studies included in our review support the use of heel QUS measurement as a feasible BMD screening method that can be utilized by pharmacists [36]. Although QUS is no better than questionnaires based on simple risk factors, such as age, body weight, and sex in predicting those likely to have low BMD [43], offering a clinical service such as BMD measurement may be important for the success of pharmacy-led osteoporosis interventions. In fact, one of the trials included in our review that compared patient satisfaction between two different pharmacist interventions found that peripheral BMD testing was important for patient recruitment and satisfaction [34]. Further research is needed to clarify the importance of BMD measurement on the success of community-based osteoporosis interventions.

Our study has many strengths, including a thorough systematic search of the literature, having two independent reviewers search for an abstract data and having a third author to resolve discrepancies. We also focused on RCT study designs. Nonetheless, our results are limited to the quality and generalizability of the RCT studies identified. In fact, due to high risk of bias in two of the RCTs under review, non-experimental studies may have yielded similar quality results. If no plan exists to disseminate interventions outside a local setting, lower-quality evidence may be acceptable in quality improvement [44]. Evidence from non-experimental studies may thus be informative for local quality improvement interventions.

Our study is also limited by qualitative assessment of risk of bias, which we ascribed as low or high risk based on our assessment of whether or not evidence existed to suggest that results may be biased. We had originally considered two quality assessment tools [45, 46] used in prior reviews of pharmacist interventions [8, 39–41]. However, upon the application of these quality assessment tools, we found that neither differentiated between the studies well. The first largely focused on the quality of reporting methods [45], and we found the second to be more relevant to drug interventions than healthcare interventions [46]. We therefore decided to examine the risk of bias qualitatively grouped under the main headings of information bias and selection bias, and ascribed "low risk" when we noted little evidence of potential bias, and "high risk" when we noted some evidence of potential bias. Further work to provide better quality assessment tools for healthcare interventions is needed.

Although our findings suggest that community pharmacist interventions may help to improve the identification of individuals at risk for osteoporosis through improved DXA testing, further study is important to determine the feasibility of interventions in community pharmacies. We note that the two trials with positive findings were completed in: (1) a network of pharmacies that had pharmacists with advanced training and experience in research participation [35] and (2) community pharmacies within the same pharmacy chain [36]. In addition, the one other RCT included in our review had excluded pharmacies deemed to have too few staff or insufficient space [34]. Therefore, the generalizability and feasibility to other settings need to be explored. We also note that none of the studies examined the impact of the pharmacist interventions on osteoporosis treatment adherence or considered pharmacists' experience or satisfaction with the osteoporosis management programs. Recent reviews of the literature identify that strategies that enhance patient and healthcare provider communication and treatment follow-up may be key to improving adherence to osteoporosis pharmacotherapy [5, 47, 48]. Further study is thus important to identify the impact of pharmacy interventions on treatment initiation and adherence to therapy, as well as to examine the feasibility of osteoporosis management in community pharmacy. Interventions in osteoporosis management by physicians, physiotherapists, nurses, dieticians, and other healthcare professionals working in teams have helped to improve treatment adherence and calcium intake among community-dwelling women [5] and increase BMD testing and osteoporosis treatment rates in patients post-fracture [4].

Conclusions

Pharmacists are in a unique position to help reduce the burden of osteoporosis by improving the identification of high-risk patients for treatment, especially those on corticosteroid therapy. Results from our review suggest that pharmacist identification and counseling of patients at risk for osteoporosis results in higher DXA testing and improvements in calcium intake. Further high-quality evidence is needed to determine the feasibility of osteoporosis management in pharmacy practice settings, to examine the comparative effectiveness of different pharmacy intervention strategies, and to address the impact of pharmacist interventions on osteoporosis treatment adherence.

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Conflicts of interest None.

Appendix

Table 4 Search strategy for MEDLINE, EMBASE, *IPA*, and HealthStar done April 20, 2010

	Search Terms	Ovid MEDLINE[a] Results	Ovid EMBASE[b] Results	Ovid *IPA*[c] Results	Ovid Healthstar[d] Results
1	*Osteoporosis/	19560	21737	1901	11099
2	osteoporos#s.tw.	34026	35796	1880	19752
3	bone loss$.tw.	14265	11657	315	8013
4	Bone Density/	30978	29744	251	18825
5	(bone adj2 (density or fragil$)).tw.	26293	24729	753	15811
6	bone mass.tw.	10680	10257	178	5320
7	bmd.tw.	14102	13432	260	8703
8	exp Fractures, Bone/	117949	119884		77165
9	Fracture$.tw.	138210	121797	1370	87072
10	Postmenopause/	14361	27716	1238	12392
11	(post menopaus$ or postmenopaus$ or post-menopaus$).tw.	36291	36928	2055	26297
12	Or/1-11	252732	230223	4698	155406
13	pharmacist.mp. or exp Pharmacists/	11583	28008	29688	10896
14	exp Pharmacy/or pharmacy.mp.	43253	41432	57688	31208
15	or/13-14	48773	55457	70287	36175
16	12 and 15	277	402	292	214
17	limit 16 to English language	268	351	288	210
18	remove duplicates from 17	261	315	200	178

PubMed Search Terms (*Osteoporosis/OR Osteoporos OR Bone loss OR Bone Density/OR bone mass OR bmd OR exp Fractures, Bone/OR Fracture OR Postmenopause/OR (post menopause or postmenopause or post-menopause)) AND (Pharmacists/OR pharmacist); Results: 118 articles

[a] Ovid MEDLINE(R) (1950 to April Week 1 2010), OLDMEDLINE(R) (1947 to 1965), MEDLINE(R) Corrections, MEDLINE(R) In-Process & Other Non-Indexed Citations (April 19 2010)

[b] EMBASE (1980 to 2010 week 15), EMBASE Classic (1947 to 1979)

[c] International Pharmaceutical Abstracts (1970 to April 2010)

[d] Ovid Healthstar (1966 to March 2010)

Table 5 Grey literature search, completed June 2009 and May 2010

Grey Literature
Centre for Health Services and Policy Research, University of British Columbia, http://www.chspr.ubc.ca/cgi-bin/pub
University of Ottawa Evidence-based Practice Center (EPC), http://www.chalmersresearch.com/old/systematic_reviews_publications.htm
Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S), http://www.surgeons.org/AM/Template.cfm?Section=Home&Template=/Templates/HomeRACS.cfm
Department of Health and Ageing, Australian Government, http://www.health.gov.au/internet/main/publishing.nsf/Content/health-publicat.htm
Belgian Health Care Knowledge Centre, http://www.kce.fgov.be/index_en.aspx?SGREF=5211
International Network of Agencies for Health Technology Assessment, http://www.inahta.org/
European network for Health Technology Assessment – EUnetHTA, http://www.eunethta.net/Public/About_EUnetHTA/
Finnish Office for Health Technology Assessment (Finohta), National Research and Development Centre for Welfare and Health (STAKES), http://finohta.stakes.fi/EN/index.htm
French National Authority for Health/Haute Autorité de santé (HAS), http://www.has-sante.fr/portail/display.jsp?id=c_5443&pcid=c_5443
German Institute of Medical Documentation and Information (DIMDI), Federal Ministry of Health, http://www.dimdi.de/dynamic/en/hta/db/index.htm
Health Service Executive (HSE)/Feidhmeannacht na Seirbhíse Sláinte, http://www.hse.ie/en/Publications/
Health Council of the Netherlands/De Gezondheidsraad, http://www.gezondheidsraad.nl/en
Catalan Agency for Health Technology Assessment and Research (CAHTA)/Agència d'Avaluació de Tecnologia i Recerca Mèdiques de Catalunya, http://www.gencat.net
Swedish Council on Technology Assessment in Health Care (SBU), http://www.sbu.se/en/
Aggressive Research Intelligence Facility (ARIF), Department of Public Health and Epidemiology, Department of General Practice, and the Health Services Management Centre; University of Birmingham, http://www.arif.bham.ac.uk
Agency for Healthcare Research and Quality (AHRQ) (Technology Assessments), http://www.ahrq.gov/clinic/techix.htm, http://www.ahrq.gov/clinic/epcquick.htm, http://www.ahrq.gov/clinic/epc/epcprogress.htm
Department of Veterans Affairs Research & Development, http://www.research.va.gov/resources/pubs/default.cfm, http://www.va.gov/vatap/publications.htm
ECRI (Emergency Care Research Institute), http://www.ecri.org/
Institute for Clinical Systems Improvement (ICSI), http://www.icsi.org
University HealthSystem Consortium (UHC), http://www.uhc.edu/
Canadian Task Force on Preventive Health Care, http://www.ctfphc.org/list_all_topics.htm
CMA Infobase, Canadian Medical Association, http://mdm.ca/cpgsnew/cpgs/index.asp
Toward Optimized Practice (TOP), Alberta, http://www.topalbertadoctors.org/cpg.html
Aetna Clinical Policy Bulletins, http://www.aetna.com/products/rx/pcpb_menu.html
Intute, http://www.intute.ac.uk/
National Research Register (NRR), National Institute for Health Research, UK, https://portal.nihr.ac.uk/Pages/NRRArchive.aspx
The Cochrane Collaboration, http://www2.cochrane.org/reviews/
Osteoporosis Canada, http://www.osteoporosis.ca/
National Osteoporosis Foundation (NOF), http://www.nof.org/
Canadian Pharmacists Association, http://www.pharmacists.ca/
National Community Pharmacists Association (NCPA), http://www.ncpanet.org/

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