Practice nurse involvement in the management of adults with type 2 diabetes mellitus attending a general practice: results from a systematic review

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ABSTRACT

Aim: Using the methodology of the Joanna Briggs Institute, a systematic review of current research was performed to determine if the addition of management by nurses had been more effective in improving clinical outcomes of patients with type 2 diabetes attending a general practice compared with standard care.

Methods: A three-step literature search was conducted for suitable English studies with quantitative clinical outcomes that had been published from January 1990 to May 2014. Randomised controlled trials (RCTs) were particularly sought after; however, other research designs were considered. Articles were assessed by two independent reviewers for methodological validity, prior to inclusion in the review, using standardised critical appraisal instruments from the Joanna Briggs Institute. When possible, quantitative data were pooled in statistical meta-analysis.

Results: Seven studies were of suitable quality and relevance for the review: these included three randomised control trials; two cluster-RCTs; a cluster, nonrandomised, controlled before-after study; and a cluster observational cohort study. These studies yield evidence that nurse management in addition to standard general practitioner care leads to modest improvements in blood pressure and total cholesterol levels in adults with type 2 diabetes attending a general practice.

Conclusion: Meta-analysis identified modest, significant improvements amongst participants in nurse management interventions (NMIs) in the following clinical outcomes: mean SBP, mean DBP and mean total cholesterol. The majority of outcomes studied did not show any advantage to adding NMIs to general practitioner care. Two studies reported significant improvements of participants with poor control in mean haemoglobin A1c. An RCT that investigates the effect of NMIs on patients, with poor control in regard to clinical outcomes and cost effectiveness, is recommended.

Key words: diabetes mellitus type 2, general practice, meta-analysis, nurse management, practice nurse

Background

In the year 1996, diabetes was first listed as an Australian national health priority.1 Now 5% of Australian city-dwellers live with this disease, and in remote areas, it is estimated that one out of every 11 people has diabetes.2

Type 2 diabetes accounts for 85–90% of all diabetes cases, and each week in Australia approximately 1160 new cases of type 2 diabetes are identified.1,3 The increase rate in type 2 diabetes occurrences has been a worrying trend, as it often leads to debilitating symptoms and an early death. It is associated with circulatory complications, chronic kidney disease, eye complications and a significant reduction in quality of life.4 In 2010, 5.4% (7750/143 519) of Australian deaths were the result of diabetes or causes related to diabetes.2
In 2008–2009, almost $1507 million was spent on diabetes in Australia. Of this, 43% was on hospital-admitted patients, 24% on out-of-hospital medical services and 33% on blood glucose lowering medicines. Diabetes management is a drain on one’s personal finances as well. On average, the direct individual medical costs of someone with diabetes are two to three times above the average.3

As with other chronic diseases, the management of diabetes is complex, time consuming and challenging. Studies have shown that approximately 50% of patients with chronic diseases do not receive suitable management.6,7 Such findings have led to calls for a paradigm shift in how healthcare is delivered to patients who have a chronic disease. Ongoing research continues to search for methods to manage chronic disease that are cost-effective, accessible and widely available.8

Evidence has identified nurses to be well suited to deliver education on health and illness prevention to patients with chronic diseases. Nurses employed in general practice (i.e. practice nurses) are particularly well placed to implement behaviour change strategies and to monitor patient compliance. Data from international studies confirm that nurses working in general practice effectively manage the complex needs of patients with chronic diseases.9 A systematic review by Laurant et al.9 concluded that interventions that replaced doctors in primary care with properly trained nurses resulted in comparable processes of care, utilisation of resources, costs and patient health outcomes.

In the United Kingdom, nurses have long participated in the management of chronic diseases.10 In Australia, a recent national survey of Australian practice nurses with a response rate of 32% (n = 701/2161) verifies that the growing role of the Australian practice nurse includes chronic disease management.11 The proportions of practice nurses that reported that they undertook education, assessment and management on a weekly or daily basis for specific chronic diseases were as follows: asthma (46%), arthritis (29%), cardiovascular disease (76%), diabetes (59%) and wound management (93%).11 Approximately half (52%) reported that they frequently prepared chronic disease management plans.11 It has been suggested by Jolly12 that up to 70% of work performed by doctors in Australian general practice could actually be performed well by nurses. The number of Australian practices employing a nurse has been climbing over the last decade; in 2007, 58% of general practitioners (GPs) employed a nurse and in 2012, this figure rose to 63%.11 In 2012, there were 10,693 nurses employed at a GP; nearly 3000 more than those employed in GPs in 2007.11

Some believe that adults with type 2 diabetes would benefit by having nurses involved with their management, and several studies have shown that nurses working with doctors in general practice significantly improved outcomes in patients with type 2 diabetes.13–17 Although improvements in the patients’ glycaemic control have been reported, Renders et al.18 have called for researchers to focus more broadly on the clinical outcomes in interventions to improve the management of diabetes in general practice, outpatient and community settings.

Aims
The aim of this systematic review was to determine if the additional management by nonspecialist nurses was more effective in improving clinical outcomes of patients with type 2 diabetes in general practice than standard GP care alone. This review is an update of a 2012 review.19 Studies with interventions performed by a nurse practitioner, a diabetic nurse educator or a study nurse were excluded from the review to retain focus on nonspecialist nurses, often referred to as practice nurses, employed in general practice.

Search strategy
A search strategy was designed to identify peer-reviewed scientific articles as well as other types of research publications, for example, doctoral theses or government reports. The search was limited to publications written in English and was undertaken in three steps. First, an initial limited search of Medline and CINAHL involved an analysis of the title, abstract and index terms of relevant articles to identify relevant search terms. Next, identified search terms were used to search relevant databases, and, lastly, the reference lists of all identified articles were manually searched for additional studies.

The search strategy was designed to identify both published and unpublished literature. The first published search was limited to English language articles published from January 1990 to December 2011. After publication of the source report, the search was rerun in July 2014, to update the review for this article, using the same search strategy. This 2014 search resulted in two new articles, published after 2012, being included in the review. Therefore, the final search for this article was performed in 2014, and, in total, the literature for this article was searched from 1990–2014.

Initial keywords used were as follows: diabetes, diabetes mellitus, type 2 diabetes, nurse-led, nurse-directed, practice nurse, primary care, primary healthcare, general practice, family practice and GP.
Twenty-four databases for published literature were searched; these included but were not limited to CINAHL, EMBASE, Medline, PubMed and Scirus. Fourteen databases containing unpublished literature were searched that included but were not limited to the following: American Nurses Association, Australian Digital Theses Program, Google Scholar System for Information on Grey Literature in Europe. A full list of the databases used in the search can be found in the source report.19

The following specific search strategy was applied: nurse-led OR nurse-run OR nurse-directed OR ‘nurse managed’ OR ‘nurse coordinated’ OR ‘shared care’ AND ‘general practice’ OR ‘family practice’ OR ‘primary care’ OR ‘primary healthcare’ AND ‘diabetes’ AND ‘RCT’ OR ‘random allocation’ OR ‘randomised control trial’ OR ‘comparative study’ OR ‘interrupted time series’ OR ‘clinical trial’ OR ‘prospective study’ OR ‘study design’ OR ‘evaluation research’ OR ‘controlled study’ OR ‘cohort’ OR ‘case control’ OR ‘interrupted time series’ OR ‘experimental study’.

Inclusion criteria
Studies of nurse management interventions (NMIs) involving adult participants (aged above 18 years) diagnosed with diabetes type 2, attending a general/family practice, were reviewed. Only studies that involved a nurse who was both employed by the practice and played a lead role in the intervention care were included. Studies using a randomised controlled trial (RCT) or a cluster RCT (cRCT) design were particularly sought after; however, other research designs (i.e. controlled clinical trials, interrupted time series, controlled before and after designs and observational studies) were considered as well. Studies were selected that reported on changes in one or more clinical outcomes for example, SBP, DBP, BMI, cholesterol levels, haemoglobin A1c (HbA1c) and fasting blood glucose.

Methods of the review
Study appraisal
A Joanna Briggs Institute (JBI) approach was used for the review. Studies were assessed by two independent reviewers for methodological quality using one of two standardised critical appraisal instruments, which are part of the JBI Meta-analysis of Statistical Assessment and Review Instrument (JBI-MAStARI). The JBI-MAStARI tools offer a list of criteria and reviewers assess whether each criterion was met (yes, no or unclear). The studies were appraised for aspects such as randomisation/allocation, blinding, measure methods, group comparison and statistical analysis. The reviewer determined if the study had met the criterion with a yes, no or unclear. To be included in the review, a study had to meet at least five out of ten criteria (‘yes’ by both reviewers) for experimental studies or nine for case control, cohort and descriptive studies. A third reviewer was used to resolve any disagreements. The results of this assessment can be viewed in Table 1; question numbers in the table correspond with those on the published tool. Specific details about the interventions, study populations, methods and outcomes of significance to the review question and specific objectives were extracted from articles using the standardised data extraction tool from JBI-MAStARI.

Meta-analysis
When possible, quantitative data from the studies were pooled in statistical meta-analysis using RevMan 5 (Cochrane Collaboration). Some studies did not report/provide standard deviations and/or 12 month mean data25 and were excluded from the meta-analysis. For

Table 1. Results of JBI-MAStARI critical appraisal of included studies

<table>
<thead>
<tr>
<th>Reference</th>
<th>cRCT</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
</tr>
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<tbody>
<tr>
<td>Blackberry et al.21</td>
<td>cRCT</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Cleveringa et al. 2008</td>
<td>cRCT</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>U</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
</tr>
<tr>
<td>Gabbay et al. 200628</td>
<td>RCT</td>
<td>Y</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Meulepas et al.27</td>
<td>cCBA</td>
<td>N</td>
<td>U</td>
<td>N</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
</tr>
<tr>
<td>Taylor et al. 200329</td>
<td>RCT</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>N</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
</tr>
<tr>
<td>Taylor et al. 200529</td>
<td>RCT</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
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<tr>
<th>Reference</th>
<th>CC</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
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<tbody>
<tr>
<td>Juul et al.25</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

* cCBA, cluster controlled before after; cOC, cluster observational cohort; cRCT, cluster RCT; N, no the criterion was not met; N/A, not applicable; Q, question; U, it was unclear if the criterion was met; Y, yes the criterion was met.
each forest plot, experimental condition was used to denote the NMI group and control to denote the usual care/GP intervention group. RevMan 5 (Cochrane Collaboration) was used to create forest plots of the meta-analysis results. All quantitative data were entered twice. Wherever appropriate, relative risks and/or odds ratios and their associated 95% confidence interval were calculated for analysis of categorical data. For continuous data that had been collected using the same scale, weighted mean differences and standard deviations were calculated; for data collected using different scales, standardised mean differences were calculated. Significant heterogeneity was assumed at \( P < 0.1 \) using the chi-square test for homogeneity. As the interventions were complex and varied, heterogeneity was anticipated in the meta-analysis, and a random effects meta-analysis was utilised.

Four studies used a cluster design in which groups of individuals are organised to receive either intervention or control treatment rather than individuals being organised to receive either intervention or control treatment. In all four included cluster studies, the GP clinic was the unit of allocation. For the Blackberry et al.\(^{21}\) and Cleveringa et al.\(^{26}\) studies, the research team randomised the GP clinics to receive either intervention or control, whereas the Meulepas et al.\(^{27}\) and Juul et al.\(^{25}\) studies collected data from GP clinics that were providing intervention or control treatment for their patients for non-random reasons independent of the research study. There are advantages to using a cluster designs, and it is a valid approach; it is also acceptable to combine cRCTs with RCTs in a meta-analysis,\(^{22}\) as long as the effect of the intervention on a cluster design and individual design are considered comparable,\(^{23}\) as they are in this case. However, as participants within a cluster have a tendency to be more alike than they are to participants in other clusters, this design requires special treatment. We adhered to recommendations to adjust data from included cluster studies, when needed, to avoid unit-of-analysis errors;\(^{22}\) and to assess cluster studies for cluster-specific bias,\(^{23}\) as shown in Table 2.

Blackberry et al.\(^{21}\) and Meulepas et al.\(^{27}\) each adjusted for clustering in their analysis as well as reporting raw data. Cleveringa et al.\(^ {26}\) mention adjusting for clustering in the power analysis; however, it was unclear if they adjusted for clustering when calculating their results. Blackberry et al.\(^{21}\) reported an intracluster correlation coefficient (ICC) value, a measure of the amount of clustering in a sample, for each outcome. Meulepas et al.\(^{27}\) adjusted for clustering using a published ICC (0.05) that was appropriate for use in studies where the allocation unit is a GP clinic.\(^ {24}\) We used this same published ICC (0.05) to adjust the Cleveringa et al.\(^ {26}\) data for clustering or to adjust the raw dichotomous data from Blackberry et al.\(^ {21}\) or Meulepas et al.\(^ {27}\) We adjusted the data for clustering, using a method recommended by Cochrane, that for continuous variables involved using the ICC to reduce the sample size resulting in the calculation of effective sample size and for dichotomous variables using the ICC to reduce both the number of events and sample size.\(^ {22}\) Juul et al.\(^ {25}\) report that they adjusted for clustering in the analysis of their data; they had estimated differences in mean proportions by binomial regressions with identity link, systematic effect of type of practices and random difference between practices.

### Results

The updated search led to the inclusion of two more articles, which brought our total yield to seven peer-reviewed research articles that were methodically assessed for inclusion (Fig. 1), resulting in seven final articles that originated from Australia, the United States, Canada, the Netherlands and Denmark. The main reason for related studies to be excluded was that the nurse was a diabetes educator, an advanced practice nurse or nurse practitioner or that the nurse had an unclear or minor contribution within a multidisciplinary intervention.

### Table 2. Assessment of bias in included cluster studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Recruited patients before clusters randomised</th>
<th>Baseline balanced</th>
<th>Data was collected from all clusters</th>
<th>Analysis adjusted for clustering</th>
<th>Comparable with individual trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackberry et al.(^{21})</td>
<td>cRCT</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Cleveringa et al. 2008(^ {26})</td>
<td>cRCT</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Meulepas et al.(^ {27})</td>
<td>cCBA</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Juul et al.(^ {25})</td>
<td>cOC</td>
<td>N/A</td>
<td>N/A</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

\( \text{cCBA} \), cluster controlled before after; \( \text{cOC} \), cluster observational cohort; \( \text{cRCT} \), cluster RCT.
Individual reasons for exclusion are reported in the source review.  

The interventions
NMIs were varied and included both individual and group education for participants on lifestyle, medication adjustment and treatment decisions based on algorithms (Table 3). In Blackberry et al., this education occurred over the telephone. In the Taylor et al. study, practice nurses titrated medications for diabetes, cholesterol and hypertension following algorithms based on national guidelines. Two studies used a computer decision support system. Outcomes reported in the seven reviewed studies included one or more of the following: HbA1c, fasting blood glucose, lipids [total cholesterol (TC), LDL], BMI, SBP or DBP (Table 3).

Main clinical outcomes
Glycated haemoglobin A1c
All seven included studies assessed HbA1c. Meta-analysis performed on the final mean HbA1c values of four of these studies did not identify any advantage to participants who had received the NMIs as compared with standard GP care (Fig. 2). The results of Taylor et al., which were not included in the meta-analysis because the standard deviation data were not reported, described an advantage to participants receiving the NMI at 4 months that approached significance ($P = 0.10$). The cluster observational cohort study performed by Juul et al. found comparable mean HbA1c values when comparing practices with well-implemented nurse-led diabetes consultations to practices that did not have a nurse. The study of Taylor et al. was excluded from the meta-analysis as it was limited to participants with long-standing diabetes, one or more major medical comorbid conditions and an HbA1c greater than 10% at baseline. However, they did observe a significant decrease in HbA1c mean in the participants receiving NMI as compared with controls at 1 year ($P = 0.01$, effect size $0.37$).

Several studies assessed the number of participants who reached an HbA1c target. Meta-analysis combining data from two such studies, one using an HbA1c target of less than 7% and the other a target of less than 7.5%, showed that NMIs did not impact the proportion of participants that had reached the HbA1c target at
Table 3. Included studies

<table>
<thead>
<tr>
<th>Studies</th>
<th>Method/length</th>
<th>Participants</th>
<th>Interventions</th>
<th>Usual care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackberry et al.</td>
<td>Cluster RCT;</td>
<td>Sites = 59</td>
<td>Practice nurses from intervention practices received 2 days of training in a</td>
<td>Usual care by their GP, which may have included referral to diabetes educators, dietitians and diabetes socialists as part of the standard diabetes care of that practice</td>
</tr>
<tr>
<td>Victoria, Australia</td>
<td>follow-up: 18 months</td>
<td>GP clinics; participants had diabetes type 2 attending a GP; intervention n = 236 control n = 237</td>
<td>telephone coaching programme, which aimed to deliver 8 telephone and one face-to-face coaching episodes per patient</td>
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</tr>
<tr>
<td>Victoria, Australia</td>
<td>Cluster RCT;</td>
<td>Sites = 55</td>
<td>A 1 hr consultation with nurse who used a computerised decision support system (CDSS) with diagnostic and treatment algorithms and a recall system</td>
<td>Usual care was provided by the GP or a nurse under direction of the GP</td>
</tr>
<tr>
<td>Victoria, Australia</td>
<td>follow-up: 1 year</td>
<td>GP clinics participants had diabetes type 2 attending a GP; intervention n = 1699 control n = 1692</td>
<td>Nurse implemented algorithms under supervision of GP. Also included were behavioural goal setting, individualised care plans, self-management education, follow-up phone calls and referrals</td>
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<tr>
<td>Victoria, Australia</td>
<td>RCT; follow-up: 1 year</td>
<td>participants had diabetes (95% had type 2) attending a GP clinic; intervention n = 150 control n = 182</td>
<td>Practices with well implemented nurse-led type 2 diabetes consultations</td>
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<tr>
<td>Victoria, Australia</td>
<td>Cluster observational cohort study; follow-up: cholesterol: 450 days; HbA1c: 180 days</td>
<td>Sites = 193 GP clinics; participants had diabetes type 2 attending a GP; n = 13 117</td>
<td>Individual consultation with nurse to review medical, lifestyle and psychosocial status and develop self-management plan. Group classes each week for 4 weeks using a workbook and discussion format. Telephone follow-up to review patient goals, medication use, symptoms, glucose monitoring, BP monitoring and self-management activities. Nurses followed algorithms based on national guidelines to titrate medications for diabetes, cholesterol and hypertension</td>
<td>Practices with either no nurse employed or no implemented nurse-led consultations</td>
</tr>
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<td>Victoria, Australia</td>
<td>RCT; follow-up: 1 year</td>
<td>Sites = 1 GP clinic; participants had long-standing diabetes (type 2 = 97% usual care, 93% intervention) with one or more major medical comorbid conditions and an HbA1c greater than 10% at baseline attending a GP; intervention n = 61 control n = 66</td>
<td>Usual care with GP including diabetes pamphlets, Medic Alert pamphlet and instructions to maintain contact with GP and attend general diabetes classes at a local medical centre. Participants told after 1 year they would receive a workbook and meet with nurse care manager or attend a group</td>
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12 months ($P = 0.19$). At the commencement of the Taylor et al. study, 43% of participants in the NMI group had reached an HbA1c target of less than 7.5 as compared with just 25% in the control group; this difference was significant ($P < 0.03$). When assessing the reduction of participants with high HbA1c, the Meulepas et al. study found that the NMI group had a significant improvement in reducing the proportion of participants with high HbA1c ($\geq 8.5\%$) over the standard care group (OR of 0.5; 95% CI 0.3 to 0.9). In their cluster observational

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<tr>
<td>Taylor et al.(^{29}) Canada</td>
<td>RCT; follow-up: 4 months</td>
<td>Sites = 1 GP clinic participants had type 2 diabetes attending a GP; intervention $n = 20$ control $n = 19$</td>
<td>Four or five visits by nurse at home, 1 visit from a dietician (nurse present) and 1 visit from exercise physiologist. Initial visit including assessment of knowledge and education provided based on this assessment. Focus of subsequent meetings was self-management. Case conferences with usual physician for medication adjustment and advice.</td>
<td>Usual care by GP, included one quarterly scheduled visit</td>
</tr>
<tr>
<td>Meulepas et al.(^{27}) the Netherlands</td>
<td>Cluster controlled before-after study/1 year</td>
<td>GP clinics = 51; patients with type 2 diabetes attending a primary care clinic; intervention $n = 431$ control $n = 469$</td>
<td>Nurse provided information on lifestyle management for risk factors and adjusted medication at quarterly visits. Also used the diabetes support service (DSS), a patient recall register. The before mean data were comparable for HbA1c (intervention, 7.3; SD 1.2 and control, 7.2; SD 1.1); for SBP (intervention, 149; SD 22.9 and control, 150; SD 23.3); for DBP (intervention, 84; SD 12.1 and control, 84; SD 12.5); for total cholesterol (intervention, 5.0; SD 1.0 and control, 5.1; SD 0.9). The intervention and control groups each had 82% smokers, a mean BMI of 29 kg/m(^2), a mean HDL ratio of 4.3 and comparable mean triglycerides (intervention, 1.8; SD 1.2 and control, 1.9; SD 1.2).</td>
<td>Care by GP and DSS</td>
</tr>
</tbody>
</table>
**Figure 2.** When compared to usual care, nurse-led interventions did not improve HbA1c but were more effective at 1 year in reducing mean SBP, DBP and total cholesterol.
cohort study, Juul et al.\textsuperscript{25} found that compared with practices with no nurses, the mean proportion of patients with an HbA1c at least 8.0% for practices with a nurse employed was lower; this held true both in practices where nurse consultations for diabetes patients were well implemented (3.7% reduction in HbA1c; 95% CI $-6.7$ to $-0.6$) and in practices where there were nurses but no organised nurse consultations (3.2% reduction; 95% CI $-7.5$; 1.0), but this result was complicated by the fact that statistically more patients in the nurse-employed group had undergone HbA1c testing.

### Systolic blood pressure

Six of the included studies assessed participant SBP. The data of four studies that had reported mean SBP data on a total of 4983 participants\textsuperscript{21,26–28} were combined in meta-analysis and a modest, significant decrease in final mean SBP was identified in the NMI group as compared with the GP standard care group [MD $-4.40$ (95% CI $-7.06$, $-1.74$), $Z = 3.24$, $P = 0.001$] (Fig. 2). Taylor et al.\textsuperscript{29} found no mean SBP difference between intervention and control at 4 months ($P = 0.17$). Taylor et al.\textsuperscript{20}, who looked at the effect of NMIs on participants with poor HbA1c control at baseline, reported deterioration of SBP in both groups with the intervention group deteriorating less than GP standard care at 1 year (effect size of 0.28). The data of two studies that assessed the portion of participants meeting an SBP target of 140 or 150 mmHg\textsuperscript{26,27} were combined for meta-analysis; resulting in an insignificant result of OR $= 0.75$ (95% CI 0.51, 1.09), $P = 0.13$. Taylor et al.\textsuperscript{20} observed that more participants in the NMI group, as compared with the standard care group, had met a SBP target of 130 mmHg or less, yielding a $P$ value approaching significance ($P = 0.06$).

### Diastolic blood pressure

Six studies assessed participant DBP with most reporting a modest advantage to participants that had received an NMI. The mean DBP data of four studies and a total of 4982 participants\textsuperscript{21,26–28} were combined in meta-analysis, and a significant decrease in mean DBP in the NMI group as compared with usual GP care was observed [MD $-2.96$ (95% CI $-4.97$, $-0.96$), $Z = 2.90$, $P = 0.004$] (Fig. 2). Taylor et al.\textsuperscript{29} also reported a significantly greater reduction of mean DBP at 4 months in the NMI group as compared with controls ($P = 0.04$). When studying the effect of NMIs on participants with poorly controlled HbA1c at baseline, Taylor et al.\textsuperscript{20} found no advantage to being allocated to the NMI for either mean DBP or the proportion reaching a DBP target of 85 mmHg or less. Meulepas et al.\textsuperscript{27}, in contrast, observed that a significantly, slightly larger portion of participants achieved a DBP target of less than 85 mmHg in the NMI group than the control group, OR of 1.4 (1.0–2.1).

### Total cholesterol

TC was assessed in all of the included studies with the exception of the Gabbay study.\textsuperscript{28} Meta-analysis was performed combining the data of 4676 participants from three studies,\textsuperscript{21,26,27} and a statistically significant, modest improvement in mean TC was observed in participants receiving NMIs as compared with those receiving standard care [MD $-0.14$ (95% CI $-0.24$, $-0.05$), $Z = 2.98$, $P < 0.003$] (Fig. 2). Taylor et al.\textsuperscript{29} did not observe a difference between intervention and control at 4 months for mean TC ($P = 0.97$). When studying participants with poor HbA1c control at baseline, however, Taylor et al.\textsuperscript{20} observed a significantly greater improvement of mean TC amongst participants allocated to NMIs as compared with those in the control group ($P = 0.01$, effect size of 0.18). The Juul et al.\textsuperscript{25} cluster observational cohort study did not find a difference in the mean TC values of participants originating from practices with well-implemented nurse-led diabetes consultations as compared with practices that either did not employ a nurse or employed a nurse but did not have organised nurse consultations for diabetes patients.

Four studies reported on the portion of participants who met a TC target at the commencement of the study.\textsuperscript{20,26,21,25} A meta-analysis was performed combining the data of two studies\textsuperscript{26,21} and 4276 participants that measured the participants’ ability to meet a TC target of 4.5 mmol/l or less,\textsuperscript{26} or less than 5 mmol/l\textsuperscript{27} (Fig. 2). The proportion of participants that reached the target at 12 months amongst those receiving NMIs were not significantly larger than those who had received standard care OR $= 0.87$ [95% CI 0.70, 1.09] $Z = 1.21$, $P = 0.22$. Taylor et al.\textsuperscript{20} found no significant difference between NMI and standard GP care in participants with poor HbA1c control at baseline using a TC goal of less than 5.17 mmol/l. Likewise, the Juul et al.\textsuperscript{25} cluster observational cohort study did not find a significant difference comparing practices with or without a well-implemented nurse plan in regards to participants reaching a TC goal of at least 5 mmol/l.

### Low density lipoprotein

Five of the included studies assessed the effect of NMIs on LDL. One RCT\textsuperscript{24} and two cRCTs\textsuperscript{21,26,28} that had reported the mean final LDL cholesterol levels of 4123 participants were suitable for meta-analysis (Fig. 2). When combined, LDL cholesterol levels in the intervention group were comparable to those of controls [MD $-0.07$ (95% CI $-0.16$, $0.02$), $Z = 1.55$, $P = 0.12$].
(Fig. 2). Taylor et al.\textsuperscript{29} did not observe a difference between intervention and control in mean LDL at 4 months ($P = 0.98$). The study by Taylor et al.\textsuperscript{26}, looking at patients with poor HbA1c control at baseline, observed a significantly greater improvement in mean LDL ($P = 0.02$, effect size 0.330) amongst those receiving NMIs as compared with controls but no difference was observed between NMI and control groups, when measuring the proportion of participants reaching a target LDL.

**HDL cholesterol, triglycerides, fasting blood glucose, BMI, weight, smokers**

No advantage was observed for the participants receiving NMIs over GP standard care for the following outcomes: BMI, HDL cholesterol, smoking, triglycerides, mean weight. Meta-analysis was performed, when possible, which resulted in nonsignificant outcomes (Table 4). Taylor et al.\textsuperscript{26} found no significant difference between NMI and standard GP care in participants with poor HbA1c control at baseline with regards to HDL cholesterol, LDL cholesterol, triglycerides or BMI. For fasting blood glucose, however, there was greater improvement in the NMI group than in the standard care group that approached significance ($P = 0.07$).\textsuperscript{20}

**Combined outcome**

Of note, the study by Cleveringa et al.\textsuperscript{26} calculated the mean 10-year-UKPDS coronary heart disease (CHD) risk (%) of participants in NMI and control groups and found that those who had received NMIs had significantly less CHD risk; OR of 1.4, 95\% CI (0.3–2.6) $P \leq 0.05$. The following participant data had been used to calculate this odds ratio: date of onset, age, duration of diabetes, sex, ethnicity, smoking, A1C, SBP, TC and HDL cholesterol. Cleveringa also measured the proportion of participants in control and NMI groups that met four treatment targets (A1C, systolic, TC and LDL cholesterol targets) yielding a result which significantly favoured the NMI group with an OR of 1.6 (95\% CI, 1.3–2.1).\textsuperscript{26} It is unclear if the authors accounted for the effect of clustering in these analyses.

**Discussion**

Meta-analysis identified modest, significant improvements amongst participants in NMIs in the following clinical outcomes: mean SBP, DBP and TC. When looking specifically at participants with poor control, two studies reported improvements in mean HbA1c that were substantial.\textsuperscript{20,27} Meta-analysis performed on the majority of outcomes showed no difference between control and NMI groups, namely, mean HbA1c, mean triglycerides, mean weight, mean HDL cholesterol, mean LDL cholesterol, or the proportion of participants reaching a goal/target for HbA1c, SBP, DBP, TC, BMI or smoking.

**HbA1c**

The clinical outcome HbA1c is of particular importance because of the strong, well-documented correlation between HbA1c and type 2 diabetes complications.\textsuperscript{30} The HbA1c analysis, however, did not show a significant advantage for participants who had received NMIs. Cleveringa et al.\textsuperscript{26} rationalised that their negative HbA1c result had occurred ‘because mean A1C at baseline was almost at the treatment target, there was little room for improvement’. The mean HbA1c target for Cleveringa was 7% and participants’ HbA1c at baseline was certainly nearly at this target (intervention 7.1\%, control 7.0\%).\textsuperscript{26}

In contrast, the Taylor et al.\textsuperscript{20} study, by design, involved participants with poor HbA1c control at baseline (intervention mean HbA1c, 9.5\%; control mean HbA1c, 9.5\%), and significant results were achieved. In the study’s conclusion, a significant difference was observed when comparing the 1.14 mean reduction in mean HbA1c of the intervention group to the 0.35 mean reduction of those receiving standard care.\textsuperscript{20} For the cluster, controlled, before–after nonrandomised study by Meulepas et al.\textsuperscript{27}, the authors found that ‘the patient-

### Table 4. Medical outcomes that did not improve with NMIs

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Studies</th>
<th>Z Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean LDL cholesterol</td>
<td>Blackberry et al.\textsuperscript{21}; Cleveringa et al.\textsuperscript{26}; Meulepas et al.\textsuperscript{27}</td>
<td>1.55</td>
<td>0.12</td>
</tr>
<tr>
<td>Mean triglycerides</td>
<td>Blackberry et al.\textsuperscript{21}; Meulepas et al.\textsuperscript{27}</td>
<td>1.46</td>
<td>0.14</td>
</tr>
<tr>
<td>Mean weight</td>
<td>Blackberry et al.\textsuperscript{21}; Gabbay et al.\textsuperscript{28}</td>
<td>0.02</td>
<td>0.98</td>
</tr>
<tr>
<td>BMI target</td>
<td>Blackberry et al.\textsuperscript{21}; Meulepas et al.\textsuperscript{27}</td>
<td>1.12</td>
<td>0.26</td>
</tr>
<tr>
<td>HbA1c target</td>
<td>Cleveringa et al.\textsuperscript{26}; Meulepas et al.\textsuperscript{27}</td>
<td>1.32</td>
<td>0.19</td>
</tr>
<tr>
<td>SBP target</td>
<td>Cleveringa et al.\textsuperscript{26}; Meulepas et al.\textsuperscript{27}</td>
<td>1.51</td>
<td>0.13</td>
</tr>
<tr>
<td>Smoking target</td>
<td>Blackberry et al.\textsuperscript{21}; Meulepas et al.\textsuperscript{27}</td>
<td>1.39</td>
<td>0.22</td>
</tr>
<tr>
<td>Total cholesterol target</td>
<td>Cleveringa et al.\textsuperscript{26}; Meulepas et al.\textsuperscript{27}</td>
<td>1.21</td>
<td>0.16</td>
</tr>
<tr>
<td>Smoking target</td>
<td>Blackberry et al.\textsuperscript{21}; Meulepas et al.\textsuperscript{27}</td>
<td>1.39</td>
<td>0.98</td>
</tr>
</tbody>
</table>

HbA1c; glycated haemoglobin.
oriented interventions seem to especially have an effect on poorly controlled patients’. Subanalysis of participants exhibiting poor control at baseline (an HbA1c greater than 8.5%), in this study, revealed that in the study’s conclusion at 1 year, the number of participants with an HbA1c greater than 8.5% had halved from 13 to 6 in the intervention group, a significant difference to the reduction observed in the control group (16 to 14).27

Limitations
There were notable limitations to the review. Our meta-analysis combined studies with a mixture of intervention designs, which affected the outcome. The Taylor et al.20 study had a small sample size (intervention n = 61, control n = 66), and the study by Taylor et al.29 was hampered by both a very small sample size (intervention, n = 20; control, n = 19) as well as a very short intervention period (4 months). The authors of Taylor et al.29 acknowledged that, in all likeliness, their study had lacked the power to reach significance. Two weaknesses of the Meulepas et al.27 study need to be considered.27 Because of funding constraints, not all practices could start the intervention treatment at the same time; the first cohort formed the intervention group, and the practices on the waiting list formed the control group.27 This nonrandom allocation of participants is very likely to introduce bias. In addition, all participating practices of the Meulepas et al.27 study had already participated in Phase 1 of the study in which participants in the intervention arm received 12 months of logistic call support given the name, the diabetes support service (DSS).27 Phase 2 incorporated an NMI in half of the practices and used DSS in both intervention and control, leaving the influence of the NMI in isolation unclear.27 In Phase 1, DSS had not significantly improved HbA1c control over standard care whereas in Phase 2, significant improvements were observed with DSS together with NMI compared with DSS alone.27 It is recommended that controlled before–after studies should only be included in a systematic review if they have at least two intervention sites and two control sites, the timing period for the control and intervention groups were the same, and the intervention and control groups were comparable on key characteristics;23 the Meulepas et al.27 study meets all of these criteria. We performed a sensitivity analysis that involved running the meta-analyses without the Meulepas et al.27 data. The results of running the meta-analyses without the Meulepas et al.27 data did not differ in any substantial way to the meta-analyses that had included the Meulepas et al.27 data (data not shown).

Nurse management correlates with more management
Two studies reported on several management outcomes of interest. The practice nurse of the Gabbay et al.28 study was given authority to refer participants receiving the intervention to a dietician and/or a diabetes educator. Compared with the GP, significantly more referrals were made by the nurse who referred 70% of participants in the NMI group to a certified diabetes educator and 53% to a dietician; during this same time, the GP had referred 3% to a certified diabetes educator and 3% to a dietician.28 Gabbay et al.28 also found that participants who had received NMs had experienced significantly better process measures/screening for the following: ophthalmological exam, foot exam, microalbuminuria screening, pneumonia vaccination, dietician visit, diabetes nurse educator visit and smoking cessation counselling. In the cluster observational cohort study by Juul et al.25, participants in general practices with well-implemented nurse-led type 2 diabetes consultations were more likely (mean difference of 6%, 95% CI 1.5–11.4) to have had their HbA1c measured during the 180 days of observation than participants from practices that did not have a nurse employed.

Conclusion
As practice nurses are often afforded more time in their consultations, they may be suitable to collaborate in the care of diabetes patients, especially in remote areas of Australia where there are shortages of GPs and diabetes specialists required for treatment and management of diabetes.2 A review of the literature and subsequent meta-analysis indicates that practice nurses employed in a GP, participating in the management of adults with diabetes type 2, yielded only modest improvements in a minority of clinical outcomes. In an RCT specifically for diabetes patients with poor control at baseline, however, Taylor et al.20 observed significantly more robust reduction of mean HbA1c, SBP and DBP with an intervention that allowed nurses to titrate diabetes medications. Also of note, Gabbay et al.28 identified a correlation between nurse management and significantly improved diabetes-related screening such as increased foot exams. Well-designed RCTs are needed, which measure practice nurse management of diabetes type 2 patients with poor control on clinical outcomes that include HbA1c, SBP, DBP, TC as well as outcomes related to screenings, such as foot ulcers.

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Conflicts of interest
There are no conflicts of interest.

References