

The Quality and Effectiveness of Care Provided by Nurse Practitioners

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ABSTRACT

Evidence regarding the impact of nurse practitioners (NPs) compared to physicians (MDs) on health care quality, safety, and effectiveness was systematically reviewed. Data from 37 of 27,993 articles published from 1990–2009 were summarized into 11 aggregated outcomes. Outcomes for NPs compared to MDs (or teams without NPs) are comparable or better for all 11 outcomes reviewed. A high level of evidence indicated better serum lipid levels in patients cared for by NPs in primary care settings. A high level of evidence also indicated that patient outcomes on satisfaction with care, health status, functional status, number of emergency department visits and hospitalizations, blood glucose, blood pressure, and mortality are similar for NPs and MDs.

Keywords: nurse practitioners, quality, systematic review

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Note: Supplementary Table 1 is available online at www.npjjournal.org.

The inter-related concepts of health care access, cost, and quality are central to the ongoing health policy debate in the United States. Specific issues include the decreased number of primary care physicians,¹⁻³ escalating costs for chronic disease management,⁴ and the quality of care delivered.⁵ In health care, definitions of quality continue to evolve. The Institute of Medicine defined quality in 1990 as the “degree to which health services for individuals and populations increase the likelihood of attaining desired health outcomes and are consistent with current professional knowledge.”⁶

Quality of care includes both clinical and experiential aspects of care viewed from the patient’s perspective.⁷ Safety and effectiveness further define quality. Safe care is unlikely to injure or harm the patient.⁸ Safety is also characterized as the “freedom from accidental or preventable injuries produced by medical care.”⁹ Effective care is both based on scientific evidence and produces the intended result.¹⁰ In addition, the IOM asserts that, in order for care to be considered high quality, it should also be patient-centered, timely, efficient, and equitable.⁸

These characteristics clearly link patient preferences and care processes with quality.⁶ Donabedian, the father of health care quality, suggested that care quality could be improved by establishing standards for care structures and processes.¹¹ Patient outcomes become the ultimate measures of quality as they reflect the influence of both structures and processes of care.^{7,11-13}

Since nurse practitioner (NP) training programs were created nearly 50 years ago, NPs have assumed increasing responsibilities as providers in the health care system. Over the past 5 years, groups from many political frames of reference have suggested that NPs should play even greater roles and be granted full practice authority.¹⁴⁻¹⁸ At this critical time, we need to know to what extent NPs contribute to the quality, safety, and effectiveness of health care. Without further information in this area, it is difficult to determine how to best integrate NPs to improve access to health care or which models of care achieve the highest quality. These knowledge gaps must be filled when the health care needs of society are so great.

Over the past 35 years, several reviews and meta-analyses have sought to assess what is known about NP

practice.¹⁹⁻²⁷ Results indicate that care involving NPs, compared with care without them, is associated with better outcomes in terms of blood pressure^{20,21,27} and blood glucose control²⁷ and for hospital length of stay (LOS).²⁶ Outcomes are similar^{19,25,26} or better^{21-23,27} in terms of patient satisfaction and symptom management.^{19-21,25-27} Patient health status,^{22,23,26} functional status,^{21,26,27} use of the emergency department (ED),^{23,27} and hospitalizations^{23,26} are also similar among patients cared for by NPs or by other providers.

While previous systematic reviews and meta-analyses provide some insights into NP effects on specific outcomes, they are dated, restrict their analysis to primary care settings, or include studies in a variety of countries where NP educational background and practice parameters differ widely. A comprehensive review of the scientific literature on the care provided by NPs in the US is needed to inform educational, organizational, and health policy. By filling that need, the review reported here strengthens and extends the conclusions drawn from previous reviews. It does so by including studies published over the past 18 years that examine US NPs exclusively, examining outcomes of care provided to any patient population and in any setting, and without restricting patient outcomes reported.

The purpose of this systematic review was to answer the following question: How do NPs affect patient outcomes on measures of care quality, safety, and effectiveness? The study is part of a larger systematic review of the outcomes from the 4 advanced practice nurse (APN) groups: NPs, clinical nurse specialists, certified nurse-midwives, and certified registered nurse anesthetists.^{28,29} For the larger study, the research question was intentionally broad to encompass as many outcomes as possible: "How do APNs affect the safety, quality, and effectiveness of care?" Readers who are interested can find the results from the larger systematic review described in more detail in the main review report.^{28,29} This article's focus on NP outcomes provides greater depth of description of the NP studies reviewed (patient populations, practice characteristics, measures used, etc) and integrates findings from this work with existing evidence on NP outcomes.

METHODS

The systematic approach used for this review included identifying and selecting relevant studies,

reviewing and rating the individual studies, and then synthesizing findings on patient outcomes and grading the aggregated results. The project team comprised nurses, a physician, health services researchers, and experts on systematic reviews.

Data Sources and Searches

A sensitive search strategy was developed with the assistance of a science search library specialist and a technical expert panel (TEP) comprising NPs with expertise in professional practice, NP education, and outcomes review. A variety of terms used to refer to NPs (eg, advanced practice nurse, MD extender, nurse clinician, nurse consultant) were used in addition to the terms *outcome*, *quality*, *safety*, and *effectiveness*, and a broad variety of other associated terms (eg, quality of care, costs, errors, malpractice) to search for articles. The search string with MeSH terms are listed in the main study report.^{28,29} The following databases were searched systematically: Proquest, Cochrane, Pub Med, and the Cumulative Index to Nursing and Allied Health Literature.

Study Selection

Studies that met the following criteria were included: randomized controlled trial (RCT) or observational study of at least 2 groups of providers (eg, NP working alone or in a team compared to other individual providers working alone or in teams without an NP), carried out in the US between 1990 and 2009, with patient outcomes for quality, safety, or effectiveness reported.^{28,29} Studies conducted outside the US were excluded because NP education, role implementation, and scope of practice in other countries are different and access, insurance, costs of care, and other characteristics of health care systems in other countries vary significantly from the US.

Studies in which NPs worked autonomously or in collaboration with MDs, as compared to MDs working autonomously or in collaboration with other MDs, were included with the knowledge that the critical difference between these 2 provider groups was the addition of the NP. Because provider practice and health care interventions change over time, studies prior to 1990 were excluded. Studies reporting only processes of care (eg, self report of completion of selected patient assessments

or care documentation) were not included as they measure care delivery and practice activities rather than actual health outcomes. Studies were also excluded if they were not published in English or failed to report quantitative data or outcomes that could reasonably be expected to be affected by NPs.

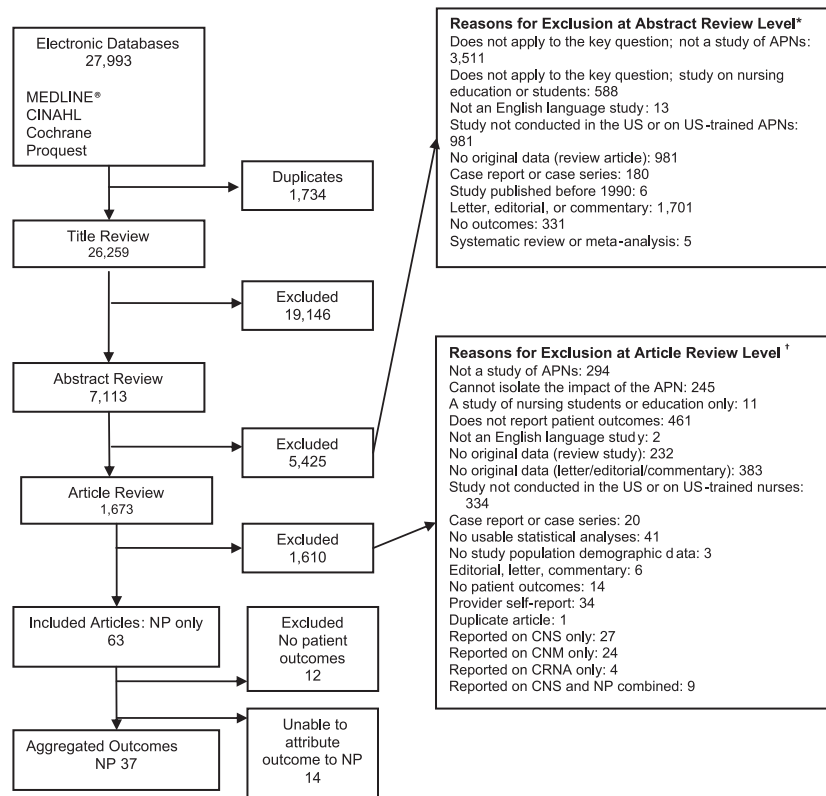
The review proceeded from titles to abstracts and then to the full articles following a sequential multi-step process (Figure 1). The Web-based database software TrialStat[®] was used to store and organize all citations, develop standardized abstraction forms for the review, and allow reviewers to access the studies. Two independent reviewers examined and determined, according to the criteria listed above, whether to include or exclude each title, abstract, and full article. If articles met inclusion criteria after examination by both reviewers, they were included in the final data abstraction. Differences of opinion regarding article eligibility were resolved through consensus adjudication.

Data Extraction and Quality Assessment

After applying the criteria described above, a sequential review process was used to abstract data from remaining articles. Data abstraction forms were completed by the primary reviewer and checked for completeness and accuracy by the second reviewer. Personnel with both clinical and methodological expertise were included in reviewer pairs. The reviews were not blinded. Consensus adjudication was used if differences of opinion between the reviewers could not be otherwise resolved.

Quality assessment is used in a systematic review to examine potential threats from individual studies to the validity of the findings. The Jadad scale (designed for RCTs that use double-blinding, etc), which quantifies the presence or absence of certain design characteristics, is commonly used to assess quality.³⁰ A modified quality scale informed by the Jadad scale was developed to better assess the quality of studies (both

Figure 1. Summary of Literature Search (Number of Articles)



Note: Reason for study exclusion can be attributable to more than 1 category

APN = advanced practice nurse; CNS = clinical nurse specialist; CNM = clinical nurse midwife; CRNA = certified registered nurse anesthetist; NP = nurse practitioner.

RCTs and observational studies) represented in this review (eg, similarity of groups and settings, group sample sizes, potential sources of bias).^{28,29}

The quality of each study was independently rated by 2 reviewers using the modified Jadad and scale items scored differently by the 2 reviewers were discussed. The modified Jadad scale yielded scores ranging from 0–8. A study quality score of ≥ 5 was considered to be high quality, and a score of ≤ 4 was considered to be low quality. These categories were determined independent of score distribution and based on the judgment that a study scoring ≤ 4 was likely to represent high bias and low attribution. The same criteria and cut points were used for both RCT and observational studies.

Data Synthesis and Analysis

While studies reporting a broad range of outcomes were included, only outcomes that were reported by at least 3 studies were selected to aggregate. The study results for these outcomes were summarized. A 2-step process was then used to evaluate the quantity and consistency of the evidence strength. First, the strength of the evidence from the aggregated outcomes was assigned a baseline grade of high, moderate, low, or very low. The initial strength of evidence was graded as high if it was supported by at least 2 RCTs or 1 RCT and 2 high-quality observational studies. The initial strength of evidence grade was moderate if supported by either 1 RCT, 1 high-quality observational, and 1 low-quality observational study or by 3 high-quality observational studies. The initial strength-of-evidence grade was low when there were fewer than 3 high-quality observational studies.

Strength of the aggregated evidence was graded a second time using an adapted GRADE Working Group Criteria.³¹ This process provided a systematic, transparent, and “explicit approach to making judgments about the quality of evidence and the strength of recommendation.”³¹ The body of evidence for each outcome was graded using the adapted GRADE criteria, which included consideration of the number, design, and quality of the studies; consistency and directness of results (extent to which results directly addressed our question); and likelihood of reporting bias. Using these criteria, the baseline grade was re-examined. The grade for each outcome was

decreased by 1 level for each of the following: if the body of evidence was sparse, not of the strongest design to answer the question, had poor overall quality, results were inconsistent, or there was a possibility of reporting bias. The final strength-of-evidence grade was then assigned.

In grading the evidence, the direction of effects was evaluated as to whether it favored NPs, favored the comparison group, or made no significant difference. In many cases, showing equivalence of outcome was considered a good outcome, similar to equivalence trials where the aim is to show the therapeutic equivalence of 2 treatments.³² This was the case when comparing outcomes of care involving NPs with outcomes of care involving only physicians.

RESULTS

Figure 1 describes the summary of the literature search results and article inclusion and exclusion at each level. Sixty-three studies met inclusion criteria. Based on the decision to focus on outcomes with at least 3 supporting studies, data from 37 studies (14 RCTs and 23 observational studies) were included in outcome aggregation. A summary of study design, study groups, study purpose, patient population, outcomes, and quality of individual studies are included in [Supplementary Table 1](#) (available online at www.npjjournal.org).

Eleven patient outcomes were identified, for which results were reported in at least 3 studies. Quality of care measures reported included patient satisfaction with provider/care, patient self-assessment of perceived health status, functional status, number of unexpected ED visits, hospitalization, duration of ventilation, and hospital LOS. Effectiveness of care was represented by patient blood pressure, blood glucose, and serum lipid levels. Mortality was the only safety outcome reported.

Most studies were conducted in urban rather than rural areas. Care delivery settings varied and included primary care offices and clinics, private homes, long-term care facilities, and inpatient acute and critical care areas. NPs were, at most, master’s prepared, but years of professional experience were not reported for any providers. MDs working alone or in a group were the typical comparison group. A number of studies compared outcomes from teams that included

NPs to those of teams inclusive of medical trainees (interns, residents, and fellows).³³⁻⁴⁴ Since medical care provided by medical trainees is supervised by an attending MD who retains accountability for patient care, it was presumed that care provided by trainees reflected the influence of the attending MD.

Where not otherwise noted, it was presumed for studies conducted in inpatient hospital settings that NPs and MDs consulted daily. This frequency of consultation is common in that setting. However, in 5 of the RCTs and 5 of the observational studies, it appeared that NPs provided care with very little or no MD consultation.⁴⁵⁻⁵⁴

Aggregated Outcomes

When comparing outcomes for quality of care provided by NPs with care involving only MDs, the strength of evidence was high, indicating similar patient satisfaction with provider/care,^{33,46,48,54-56} self-report of perceived health status,^{34,41,47,48,50,55,57} functional status,^{34,50,57-64} numbers of unexpected ED visits,^{47,49,51,53,57} and hospitalization rates.^{36,37,40,44,47,51-53,57,61,64} A moderate strength of evidence indicated that care involving NPs was similar to care involving only MDs in terms of hospital LOS.^{33-40,42-44,51,53,65-67} And a low strength of evidence indicated that duration of ventilation (for adults) was similar for care involving NPs compared with care involving only MDs.^{35,38,43}

When comparing safety of care provided by NPs with care involving only MDs, the strength of evidence was high, indicating similar patient outcomes for mortality.^{34,35,38,39,42,43,52,68}

When comparing outcomes related to effectiveness of care by NPs with care involving only MDs, the strength of evidence was high, indicating similar patient outcomes for blood glucose^{45-48,55} and blood pressure.^{45,46,48,55} There was high strength of evidence of better effectiveness of care on the outcome of patient serum lipids from care provided by NPs than from care involving only MDs.^{45,55,69}

A detailed summary of the aggregated outcomes and evidence for NPs can be found online.²⁹

DISCUSSION

This systematic review of published literature between 1990 and 2009 evaluated the quality, safety,

and effectiveness of care provided by master's-prepared NPs. By assessing outcomes with US providers and patients in US settings and using intentionally broad inclusion of outcomes, this work extends previous syntheses of the research evidence about NP outcomes. On selected measures of quality, safety, and effectiveness, patient outcomes from NPs working autonomously or in collaboration with MDs are similar to those obtained from MDs working alone. This provides additional evidence that NPs provide high quality, safe, and effective patient care.

INTEGRATION OF RESULTS WITH PREVIOUS KNOWLEDGE

Quality

Results related to NP care quality found in this systematic review echoed previous reviews in that patient satisfaction with care in primary, outpatient surgical, and inpatient settings was similar to that associated with care from MDs.^{19-23,26,27} Some previous reviews found that satisfaction with NP care was better.^{21-23,27} This review included satisfaction data obtained from samples of adults and from parents of traumatically injured children and children undergoing surgery. Outcomes of health status and physical function in patients in ambulatory, home, and inpatient care settings did not differ, regardless of whether cared for by an NP or an MD. Samples of well adults and elders, as well as those with chronic illnesses and even hospitalized individuals, were included in the health and functional status reports. Previous systematic reviews and meta-analyses found similar results for these 2 care quality outcomes.^{21-23,26,27}

The comparability of impact of NPs and MDs in minimizing ED visits in samples of healthy children, adults, and elders, as well as those with chronic or debilitating illnesses, also did not differ from findings of previous reviews.^{20,25,26} The finding of comparability on rates of hospitalization among well adults, well and debilitated elders, high-risk neonates, and chronically ill children was similar to findings of previous reviews.^{21,26,27} While 1 previous systematic review reported a shorter LOS associated with NP care,²⁶ this review found that LOS, for a variety of medical and surgical problems across all age groups,

was comparable among patients cared for by either provider group. This is the first review to report on influence of provider type on ventilation duration.

Safety

Patient safety is influenced by many variables related to patient, care setting, and provider. These potentially confounding influences make it difficult to measure and interpret safety outcomes data. Mortality was the only safety outcome aggregated in this review.^{34,35,38,39,42,43,52,68}

Reports of NP care impact on other patient safety outcomes, such as medication errors, falls, hospital-acquired infections, pressure ulcers, etc, were not found. While mortality alone is a relatively insensitive care outcome measure, it is a commonly reported patient outcome in many types of research. This review is the first to report on comparability among provider teams for the safety outcome of mortality.^{34,35,38,39,42,43,52,68} This could be because this systematic review, in contrast to previous studies of outcomes from primary care only,¹⁹⁻²⁷ incorporated evidence from NPs practicing in any setting and included nursing home residents and hospitalized high-risk neonates, children, and adults.^{33-40,42-44,51,53,65-67} Studies from these additional settings would naturally be more likely to report on mortality. More research is needed regarding a broad variety of safety outcomes.

Effectiveness

Results related to NP care effectiveness from this systematic review were reminiscent of those previously reported. Primary ambulatory care involving NPs resulted in similar though not better blood pressure and blood glucose control.^{21,27} This review found that NP care was associated with better lipid control and is the first systematic review or meta-analysis to report on this particular patient outcome.^{45,55,69} Additional research is needed on this outcome and for a broader variety of care effectiveness outcomes.

METHODOLOGICAL ISSUES

Although all the reviewers were nurses, the investigator team included 2 experts in the evaluation of health care quality and effectiveness and a physician with extensive

experience conducting systematic reviews. Articles included in the review were published in peer-reviewed medical (n = 12),^{33,37,39,45,48,51,52,56,57,59,61,64} interprofessional (n = 10)^{34,36,38,43,46,47,49,53,55,60} and nursing (n = 15) journals.^{35,40,41,42,44,50,54,58,62,63,65-69} A draft of the report was reviewed by 2 independent panels of technical experts: 1 panel comprised a consumer, a statistician, and a physician leader; the other included highly respected NPs. Written comments and recommendations from these reviewers were addressed by the authors.

Limitations in the body of research reviewed should be considered when interpreting the results of this systematic review. Heterogeneity of study designs and measures, multiple time points for measuring outcomes, limited number of randomized designs, and inadequate statistical data for meta-analysis were among the methodological limitations encountered. Diffusion of treatment because of inclusion of MDs in both experimental and usual care groups was also a potential problem in some studies.^{33,34,58,60,66} In addition, the failure to fully describe the nature of the NP roles and responsibilities and the relationships of team members, including frequency and qualities of collaboration with MDs, limits the ability to replicate the models of care employed.

To address some of the limitations, the use of a modified Jadad quality score provided clear, standardized methods to ensure a robust process, including the assessment of differences in comparison groups, settings, participants, and attribution. Application of the GRADE working group criteria when assessing aggregated outcomes also disciplined decision making regarding conclusions that could be drawn.

NP AUTONOMY VS TEAM

When assessing attribution of the outcomes to the NP, it was not always clear if the NPs practiced autonomously.^{50,53,62} Conversely, it was apparent that some study protocols restricted NP activities to a narrower scope of practice than is legally authorized.^{42,57-59} Mirroring the complexities of care today, some protocols used elaborate team interventions that included care from an NP but made it difficult to directly attribute the outcome to the NP exclusively.^{45,57} Sometimes the NP assumed responsibilities that were

previously borne by an attending MD, freeing that MD for other activities.^{58,60,66} NPs were also substituted for house staff MDs.^{33,34} Attribution of the specific outcome to the NP was especially complicated when studies were conducted in acute care hospitals because NPs in those settings (neonatal and pediatric or adult acute care NPs) often practice as part of a team.^{35-40,43,44,65,66,68}

While this review was not designed to compare NPs to MDs, MDs were the comparison group in all but 1 of the studies included. This comparison is not unexpected since the NP role was developed to mitigate problems with access to care related to a shortage of primary care MDs. In addition to providing advanced nursing services (family-focused care, patient education, support of self-care management, care coordination, interprofessional communication and collaboration, etc.), NP practice activities, roles, and responsibilities are often similar to those of MDs, and NPs and MDs often work in the same practices or settings.

Future studies should examine models of care in which patient needs and provider abilities are matched to maximize utilization of all provider types to address health needs. If needs can be met by NPs, then systems should incorporate NPs to the fullest extent possible. This structure would free MDs to attend to patient needs that demand their scope of capabilities. Health care systems could then be better designed to ensure that the right professionals are available to address each patient's needs.

Future research also needs to allow a fuller examination of the outcomes of care provided by NPs in states with full legal practice authority. Future studies need to include additional care settings (eg, rural communities, private practices) and patient populations (eg, primary care of children, individuals with mental health problems). They should also compare outcomes from different providers to accepted effectiveness measures.

CONCLUSIONS

Multiple policy implications can be drawn from these results.⁷⁰ The evidence identified in this review supports the premise that outcomes of NP-provided care are equivalent to those of physicians. Thus the question of the comparability of NP/MD quality,

safety, and effectiveness of care is answered, to a very considerable degree, by this review.

A growing number of influential groups have called for the appropriate use of all qualified providers (including NPs) to address the health care needs and improve health outcomes of Americans.^{15,16,71,72} Physicians, NPs, and their respective professional organizations should use the results of this review to help initiate interprofessional discussions that could lead to better understanding of one another's roles and capabilities and, ultimately, to improved care systems in which all providers contribute to the maximum extent that their education and qualifications allow.⁷³⁻⁷⁶ These conversations might also lead to greater opportunities for NPs and MDs to be educated on a cooperative interdisciplinary basis within joint medical/nursing training programs.

NPs play an increasingly important role in providing high quality patient care in the US. The results of this systematic review will help to address concerns about whether NPs can safely augment the MD supply and support health care reform efforts aimed at expanding access to the tens of millions of newly insured Americans.

An effective health system integrates the diverse knowledge and skills of multiple types of providers who communicate and collaborate with the patient and each another and are accountable to deliver coordinated care to the patient and society.^{77,78} Health care professionals need to create better and more collaborative systems. Health care reform initiatives, such as patient-centered medical homes and accountable care organizations should be designed to examine these collaborative care models and to document the outcomes and effectiveness of alternative staffing models. Future evaluation studies of alternative workforce teams should differentiate among the provider models used. In this manner we can advance our knowledge base on the effectiveness of various workforce alternatives that will be found as our system undergoes transformation. Governmental, institutional, and payer policies need to accommodate these diverse models of care.⁷⁸

This systematic review supports previous evidence amassed over the past decade that NPs deliver high quality, safe, and effective care to a large number of patient populations in a variety of settings. NPs

practicing autonomously and in partnership with MDs have a very significant role in promoting health and providing care to diverse populations in numerous settings. In this time of health care reform and system evolution, to best meet the needs of Americans, it is essential that future models of care take full advantage of the growing number of NPs to their full potential and capabilities.^{72,79,80}

SUPPLEMENTARY DATA

A supplementary table associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.nurpra.2013.07.004>. **JNP**

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Supplementary Table 1. Summary of Study Design, Study Groups, Study Purpose, Patient Population, Outcomes, and Quality for Nurse Practitioners

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
RCTs (n = 14)					
Becker, 2005 ⁴⁵	NP and community health worker with study MD (196) Enhanced MD PCP primary care (168)	Determine effectiveness of community-based care provided by NP to that of "enhanced" PCP MD care in managing risk factors for CAD. All MDs and NPs were given prescription drug cards (free study prescriptions) to give to pts. Study MD check of pt records twice per month	African Americans, 30-59 y/o, sibling of pronands < 60 y/o admitted to 1 of 10 hospitals, no history of CAD, autoimmune disease, immediate life-threatening comorbidity, chronic steroid therapy, or current cancer therapy Urban, community-based care Unknown insurance	LDL-C ^a HDL-C Triglycerides Systolic BP ^a Diastolic BP ^a	High (5)
Bula, 1999 ⁶⁰	GNP with MD geriatrician (203) Usual MD care not described (184)	Determine if in-home comprehensive geriatric assessment by an NP prevents functional decline in community-dwelling elders. NP performed annual assessment in home. In collaboration with geriatrician, NP developed recommendations regarding specific problems, health promotion, disease prevention, and self care. GNP made home visits q3 months. Unknown frequency of MD collaboration	Community dwelling, > 74 y/o, without pre-existing functional impairment, without severe cognitive impairment or terminal illness Urban, home care, Medicare pts	Functional status ^a	High (5)
Callahan, 2006 ⁵⁹	GNP with MD collaboration (84) PCP MD only care (69)	Test effectiveness of collaborative care model using a GNP compared to care from a PCP MD for pts with Alzheimer disease. NP case manager assessed pt; met weekly with team for advice (geriatrician, geropsychiatrist, psychologist); advised caregiver re nonpharmacologic and pharmacologic therapies; educated caregivers re communications skills, coping skills, legal and financial info, exercise Met 2 visits with pt/caregivers 1st mo then 1/ month x 12 mo Weekly MD consultation available	Diagnosed with Alzheimer Community living Has caregiver English speaking Home phone Urban, university, and VAMC-affiliated clinics Government or unknown insurance	Functional status (ADL)	High (5)

continued

Supplementary Table 1. (continued)

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
Counsell, 2007 ⁵⁷	NP as part of GRACE Team with MD PCP (474) Usual MD PCP care (477)	Test of effectiveness of geriatric care management including NP delivered care. NPs performed complete geriatric assessment, discussed results at team meeting (social worker, geriatrician), shared selected protocols with PCP for continuity, implemented selected GRACE protocols via monthly face-to-face or phone contacts with pt Pt followed x 1 yr Control group MD PCPs had access to all services (social worker, geriatrician, therapies, etc) except GRACE protocols Unknown frequency of MD consultation	> 64 y/o Without ESRD or cognitive impairment Community residing English speaking Telephone access Intact hearing Established pt Income < 200% of federal poverty level Urban, home, and community care Unknown insurance	Physical SF-36 Mental SF-36 ^a Functional status (ADL) ED visits ^a Hospitalization	High (7)
Fanta, 2006 ³³	PNP and attending MD (31) Resident MD and attending MD (45)	Compare care provided by trauma PNP and trauma service house staff. NP replacing resident MDs as provider of all day-to-day assessments and care Daily MD consultation	Children between 2 mo and 17 y/o Admitted to inpatient trauma service Urban, specialty service at teaching hospital inpatients Unknown insurance	Length of stay	Low (3)
Krichbaum, 2007 ⁵⁸	GNP in collaboration with MD PCP and surgeon (23) MD PCP and surgeon alone, usual care (23)	Determine effectiveness of a GNP-coordinated model of postoperative care for elders with hip fractures. GNP coordinated postacute care, performed comprehensive assessment, pt and family teaching, care coordination, updated PCP/surgeon. Pt visits 1x/wk x 4 then 2 x/wk x 12; Pt followed x 1 yr (GNP provided no medical care, only nursing care due to restrictions imposed by participating agencies) Unknown frequency of MD consultation	> 64 y/o Hip fracture repair (DRG 209 or 210) Ambulatory Living at home or in assisted living facilities Urban, community, and home based care Medicare and unknown insurance	Functional status (ADL/IADL)	Low (3)

Lenz, 2004 ⁴⁶	NP as PCP (70) MD as PCP (64) (All PCPs = FT MD faculty at SOM or NP faculty at SON who also practiced PT at respective clinics)	Comparison of health outcomes in pts assigned to NPs or MDs for primary care. NPs as PCP providing all primary care without MD collaboration 2-year follow up No MD consultation	Adults from primarily Hispanic community Recent urgent care or ED visit; No current emergent clinical condition No current healthcare provider (Oversampled pts with asthma, DM, and HTN) English or Spanish speaker Urban, ambulatory primary care clinics associated with academic medical center Medicaid	Systolic BP Diastolic BP HbA1C Pt satisfaction with care	High (6)
Lenz, 2002 ⁴⁷	NP as PCP (47) MD as PCP (30) (All PCP = FT faculty at SOM or SON and PT at clinic)	Compare selected DM care processes and outcomes of NPs and MDs in primary care of adults with DM2. NP as PCP providing all primary care without MD collaboration 2-year follow up No MD consultation	Adults from primarily Hispanic community DM2 Recent urgent care or ED visit No current emergent clinical condition No current health care provider Adults Urban, ambulatory primary care clinics associated with academic medical center Medicaid	HgbA1C SF-36 physical and mental health ED visits Hospitalizations	High (6)
Litaker, 2003 ⁵⁵	NP with MD PCP collaboration (79) MD PCP alone (78)	Compare traditional MD-led model of care with collaborative, team-based approach for chronic disease management. NP delegated sole responsibility for implementation of evidence-based guidelines for DM and HTN mgmt; provided pt education on self mgmt; integrated pt preferences, monitored adherence, provided family support, appt reminders, and standardized care documentation forms; consulted/referred pt to MD for problems outside of care guidelines Control group did not use appt reminders or standardized care documentation forms Unknown frequency of MD consultation	Adults Mild or moderate HTN and NIDDM Without evidence of end organ complications No complex medical conditions Urban, ambulatory primary care Unknown insurance	HbA1c ^a Total cholesterol HDL ^a BP control SF-12: physical and mental health Satisfaction ^a	High (8)

continued

Supplementary Table 1. (continued)

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
Mundinger, 2000 ⁴⁸	NP group (649) MD group (391) (All PCP = FT faculty at SOM or SON and PT at clinic)	Compare outcomes for pts assigned to NPs or MDs for follow up and continuing care after ED/urgent care visits. NP as PCP providing all primary care without MD collaboration 6-mo follow up No MD consultation	Adults from primarily Hispanic community Recent urgent care or ED visit No current emergent clinical condition No current health care provider (Oversampled pts with asthma, DM, and HTN) English or Spanish speaker Urban, ambulatory primary care clinics associated with academic medical center Medicaid	Pt satisfaction SF physical and mental health Peak flow HgbA1C BP systolic BP diastolic ^a	High (8)
Nelson, 1991 ⁴⁹	PNP follow up 24 hours after ED visit (91) Standard ED discharge instructions from MD and PCP usual care (93) (62% pts given follow up appts in discharge instructions)	Test effectiveness of an NP intervention to improve parental use of early follow up care after ED visits. NP called parents 24 hours after ED visit for acute illness; provider further info re diagnosis and treatment, reinforce follow up instructions and appt info. Avail. 24/7 for any questions No MD consultation	Children < 8 y/o without chronic illness Presents with parent or caretaker Seen for infectious or emergent condition Telephone access Primary care center as usual source of care Urban, hospital ED Medicaid	ED visits	High (7)
Paez, 2006 ⁶⁹	NP case managed care in collaboration with MD PCP or cardiologist (115) MD PCP or cardiologist alone. Usual care (113)	Evaluate effects of case management by NP or standard care by PCP or cardiologist MD on lipids in pt with CAD. NP was delegated authority to prescribe for, monitor, and provide all counseling for lipid control; 1st visit within 6 wk revascularization; phone calls to pt, prn; update MD PCPs "regularly" re pt status (4% of NP time spent in this activity) Pt followed x 1 yr Unknown frequency of MD consultation	Adults undergoing revascularization procedure Urban, community care Unknown insurance (pt paid for medications)	Cholesterol ^a LDL-C ^a	High (8)

Pioro, 2001 ³⁴	NP with MD medical director (104) House staff MD with attending MD (277)	Compare resource use and outcomes of general medical pts receiving NP-based care and traditional house staff care. NP replacing resident MDs as provider of all day-to-day assessments and care (admission history and physical exam, care coordination, implement diagnostic and therapeutic plans); to minimize overnight resident influence RN protocol-based care for common problems Daily MD consultation during rounds	18-69 y/o Admit to general medical units (transfers from ICU not included) Urban, teaching hospital, inpatient 40% private insurance, 50% Medicare or Medicaid, 10% no insurance	Length of stay Mortality rate Functional status (ADL/IADL) SF-36 physical and mental health	High (5)
Stuck, 1995 ⁶¹	GNP group (170) usual MD care not described (147)	Determine if in-home comprehensive geriatric assessment by an NP prevents functional decline in community-dwelling elders. NP performed assessment and, in collaboration with geriatrician, made recommended to pt re specific problems, health promotion, disease prevention, self care. GNP made home visits q 3 mo for follow up and monitor adherence and to help pt talk with PCP re issues Unknown frequency of MD consultation	> 74 y/o Living at home without pre-existing functional impairment Without severe cognitive impairment or terminal illness No impending nursing home admission Urban, home care Medicare	Functional status (ADL/IADL) ^a Hospitalizations	High (8)
Observational (n = 23)					
Ahern, 2004 ⁵⁰	NP with MD hepatologist as needed (35) MD hepatologist alone (26)	NP follows pts started on Rebetrin for chronic hepatitis C, monitors pts, manages side effects, and teaches pts re medication MD available to see clinic pts with NP prn	> 17 y/o English speaking Acute/chronic hepatitis C With or without cirrhosis; pt naive to treatment, nonresponsive, or relapse to previous treatment Urban, ambulatory primary care Unknown insurance	SF-36 physical and mental health	Low (3)

continued

Supplementary Table 1. (continued)

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
Aigner, 2004 ⁵¹	NP and MD internist teams (132) MD internists (71) (all providers affiliated with university teaching hospital)	Compared outcomes of pts in nursing homes cared for by NP/MD team and MD only practice model. NPs performed annual history and physical exams, acute illness visits, and half the routine intermittent monitoring visits. NPs took first call weekdays. Frequency of MD consultation on a case by case basis	Residents in 8 nursing homes Unknown communities, long-term care facilities Medicare, Medicaid, and commercial insurance	Hospitalizations ED visits Length of stay	Low (4)
Aiken, 1993 ⁶³	NP (30) MD (57)	Examination of outcomes of care in HIV-infected pts receiving primary care from NPs and MDs. NPs responsible for their own panel of pts and obtained medical histories and performed physical examinations, diagnosed and treated HIV-related illnesses, prescribed meds and monitored for adverse treatment effects, ordered and interpreted diagnostic tests, and provided health education to pts. NPs advised MDs of problems requiring MD intervention. All providers followed the same research and drug protocols. Unknown frequency of MD consultation	Adult HIV/AIDS pts seen in clinic at least once Urban, ambulatory specialty clinic associated with academic medical center Medicare, Medicaid, and commercial insurance	Physical functioning (ADL)	Low (2)
Bissinger, 1997 ³⁵	NNP (35) MD house staff (35)	Evaluated the clinical outcomes for infants weighing 500-1250 gm cared for by NNPs and those cared for by house staff Unknown frequency of MD consultation	Neonates with birthweight between 500-1250 gm Admitted to NICU within first 24 hours of life Without identified congenital cardiac, genetic, or surgical conditions Urban, academic medical center-inpatient Unknown insurance	Length of stay Ventilator duration Mortality	High (5)

Borgmeyer 2008 ³⁶	PNP added to MD house staff team (29) House staff MD team (28)	Measure the effectiveness of PNP as direct care manager of children with asthma. PNP performed admission history and physical examination, developed plan of care integrating clinical pathways, document pt progress, participate in daily team rounds, communicate with all team members, teach pts/families and team members re asthma management, develop and execute comprehensive discharge plan Daily MD consultation	All children admitted to general medical units with exacerbation of asthma Urban, specialty teaching hospital-inpatient Unknown insurance	Length of stay Hospitalization	Low (4)
Dahle, 1998 ³⁷	NP and attending MDs (116) Resident and attending MDs (99)	Evaluated use of NP to manage pts admitted with uncomplicated, decompensated CHF pts in collaboration with attending MDs NPs performed admission history and physical examination and guided therapy implementing protocols in collaboration with attending MDs. Daily MD consultation	Adults admitted with decompensated heart failure Urban, academic medical center-inpatient Unknown insurance	Length of stay Hospitalization	High (5)
Garrard, 1990 ⁶⁴	NP employee of nursing home (428) Non-NP care in matched nursing home (420) 5 sets of matched nursing homes (match criteria: type ownership; part of chain; Medicare/Medicaid certification; bed size; urban/rural; state)	Prospectively evaluated impact of GNPs employed by nursing homes on quality of care and pt outcomes. NPs assumed primary care tasks usually performed by an MD and additional health services in other areas. NPs provided ongoing pt assessment and management Unknown frequency of MD consultation	Adult Nursing home resident Oriented Unknown communities, long-term care facilities Medicare, Medicaid, commercial, and private pay insurance	Functional status (ADL) Hospitalization ^a	Low (3)

continued

Supplementary Table 1. (continued)

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
Gracias, 2008 ⁶⁸	ACNP and MD intensivist team "closed" unit (461) MD intensivist team in "semi-closed" unit (919)	Determine if addition of ACNP and "closed" unit delivery of critical care services would improve compliance to care guidelines and pt outcomes Daily MD consultation	Adults All pts admitted to 1 of 2 surgical ICUs Urban, academic medical center-inpatient Unknown insurance	Mortality ^a	High (7)
Hoffman, 2005 ³⁸	ACNP and attending MD team (135) Pulmonary fellows and attending MD team (106)	Compare outcomes in subacute MICU pts managed by ACNP and attending team or pulmonary fellows and attending team. During period on service, either ACNP or MD fellow responsible for new pt admissions processes and consulting attending re diagnoses and plan of care, daily pt assessment, problem diagnosis, writing orders, and making decisions re discharge. Attending MD made daily rounds to review plans and suggest revisions prn. Daily MD consultation	Adults Admitted to subacute MICU Endotracheal tube intubation Requiring mechanical ventilation for > 24 hours Urban, academic medical center-inpatient Unknown insurance	Mortality Length of stay Duration of ventilation	High (7)
Kane, 2004 ⁵²	Evercare NP and MD (664) (44 sites) Evercare MD only (855) (44 sites) Other long-term care site (1490) (44 sites)	Evaluated care outcomes in nursing home residents provided primary care in Evercare NP-led, Evercare MD-led, and traditional MD-led delivery models. NP carries responsibility for a caseload of 100 pts and supplements MD by regularly monitoring pts, responding to changes in condition, and intervening in urgent situations; communicate with pts/families and other providers; work with nursing home staff to improve care Infrequent MD consultation	Nursing home residents enrolled in Evercare and non Evercare nursing homes Unknown communities, nursing homes Medicare or Evercare HMO	Mortality Hospitalizations ^a	Low (4)

Karlowicz, 2000 ³⁹	NNP and MD neonatologist (94) Resident and MD neonatologist (107)	Compare outcomes of health care delivered to extremely low-birthweight infants by NNPs and resident physicians. NNPs performed physical assessments, made medical diagnoses, ordered medications and diagnostic tests, performed invasive procedures (eg, intubation, insertion of arterial and venous catheters) Unknown frequency of MD consultation	Newborns admitted to NICU Born at study hospital Surviving > 12 hours after birth Without identified chromosomal or congenital malformation Urban, teaching hospital-inpatient Unknown insurance	Length of stay Mortality	High (5)
Kutzleb 2006 ⁶²	NP and MD cardiologist (13) MD cardiologist & fellows (10)	Evaluate impact on pts with heart failure of NP-directed lifestyle modifications (diet, daily weight, smoking cessation, alcohol avoidance, exercise and medication compliance, etc). NNPs saw pts in clinic monthly x 12 for physical exam, protocol-based medical therapy, NP-developed individual education plan. NP made weekly calls to follow up with pts. MD cardiologist and fellow group saw pts in clinic quarterly for physical exam, medical therapy as needed, and MD-directed lifestyle modification Unknown frequency of MD consultation	18-75 y/o with echo documented heart failure English speaking Exclusions: Other life threatening illnesses (eg, cancer); AMI or UA as cause of heart failure; dementia: chronic medication dependent psychiatric mental health condition Urban, community hospital associated clinic Unknown insurance	Functional status	Low (2)
Lambing, 2004 ⁴⁰	NP and MD geriatrician (50) Residents and MD internists (50)	Compared care activities and clinical outcomes for geriatric pts cared for by NNPs on geriatric unit to pts cared for by interns/residents on medical units. NNPs performed pt admissions and daily assessments, documented pt progress, planned care, obtained consults, performed procedures, completed discharge planning and pt/family education Daily MD consultation	Inpatient geriatric pts 60+ y/o Admitted to geriatric unit or 1 of 2 general medical units Urban teaching hospital-inpatient Medicare	Length of stay ^b Hospitalization	Low (4)

continued

Supplementary Table 1. (continued)

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
McMullen, 2001 ⁴¹	ACNP and attending MD (296) Resident and attending MD (405)	Compare pt outcomes and pt/staff and physician satisfaction with ACNP/attending MD collaborative service and traditional MD-based service Unknown frequency of MD consultation	Adults admitted to medical unit Urban academic medical center-inpatient Unknown insurance	Perceived physical health ^a Perceived mental health	Low (4)
Meyer, 2005 ⁶⁶	ACNP and surgeon team (70) Surgeons alone (145)	Examine outcomes of pts whose postoperative care was directed by ACNP in collaboration with surgeon or surgeon alone. All surgeons in private practice. All ACNPs hospital employees. ACNPs provided daily and as needed physical exams and assessments, ordered and interpreted diagnostic tests, diagnosed, treated, monitored acute and chronic illnesses, prescribed and managed medications, counseled and taught pts/families regarding nutrition and health promotion, and referred to other providers as needed Unknown frequency of MD consultation	Adults 1 of 4 cardiovascular surgery DRG Admitted to CVICU from the OR Pt of 1 of 4 usual cardiovascular surgeons Complete computerized record available Urban, private hospital-inpatient	Length of stay	High (6)
Miller, 1997 ⁶⁷	GNP and MD managed (332) PA and MD managed (174)	Comparison of impact of addition of GNP rather than PA to MD care of older adults. GNP performed admission history and physical examination, made medical diagnoses, and using mutually developed protocols, ordered medical care and pharmaceuticals, and obtained consults. GNP provided pt/family education and developed discharge plans and wrote discharge orders. NP and MD rounded independently daily, and MD rarely made changes to GNP plan of care Unknown frequency of MD consultation	Nursing home pts admitted to inpatient medical unit Urban, teaching hospital-inpatient on nonteaching service Unknown insurance	Length of stay ^a	High (5)

Paul, 2000 ⁵³	NP holds primary responsibility for pt follow up (15) MD holds primary responsibility for pt follow up (15)	Evaluation of NP-led multidisciplinary heart failure clinic. At every visit NP assessed pt and available test results, ordered appropriate tests, adjusted medications, provided pt/family education. MD saw each pt briefly to bill Medicare for visit. NP called pt between visits to assess status Brief MD consultation available at every visit	Adults with CHF seen at university hospital-affiliated clinic Unknown communities, ambulatory multidisciplinary clinic associated with academic medical center Unknown insurance	Hospitalization ^a Length of stay ED visits	Low (3)
Pinkerton, 2000 ⁵⁴	NP (80) MD (80)	Compare pt perceived health and satisfaction with care based on whether care provided only by NP or only by MD in managed care setting No MD consultation	Ambulatory > 18 y/o DM or HTN English speaking Urban, primary care practices associated with teaching hospital Medicaid	Satisfaction	High (7)
Rideout, 2007 ⁶⁵	PNP in addition to MD and nursing team (21) MD and nursing team without PNP (NR)	Evaluation of inpatient PNP care coordinator for pediatric CF pts; complete admission and daily PE and assessment of care needs; communicate with attending, residents, and nurses; schedule tests and procedures; obtain routine consults; ID and implement plans for infection control; answer pt questions and address concerns; discuss discharge needs and plans with pt; coordinate completion of discharge paperwork Unknown frequency of MD consultation	Children- young adults Cystic fibrosis Admitted to adolescent unit Urban, university-affiliated specialty hospital-inpatient Unknown insurance	Length of stay Processes of care Nurse/MD/pt satisfaction	Low (3)

continued

Supplementary Table 1. (continued)

Author, year	Study groups (n)	Study Purpose/Degree Collaboration	Patient Population/Care Setting	Outcome/Findings	Study Quality (Score)
Ruiz, 2001 ⁴²	WHNP and MD (30) Residents and MD (41)	Compare newborn outcomes for twins born to mothers receiving care in specialized twin clinic with consistent WHNP providing care using evidence-based protocol developed with perinatologist vs mothers receiving standard prenatal care. WHNPs did intake assessment preterm labor risk, laboratory, and nutritional assessment; created problem list with MD; provided home visits for social support evaluation and preterm labor and lifestyle modification teaching; weekly scored cervical exams and screens for bacterial vaginosis and treated same; reinforced teaching re preterm labor; and intervened re rest, work, and nutritional needs Unknown frequency of MD consultation	Twin pregnancy referred for care as soon as confirmed by ultrasound or by 24 weeks gestation at latest Urban, primary care practices associated with teaching hospital Unknown insurance	Length of stay ^a Perinatal mortality	High (5)
Russell, 2002 ⁴³	ACNP added to neurosurgical team (122) Neurosurgical team alone (402)	Determine clinical and financial impact of ACNP-led outcomes management program for pts in neuro ICU. NPs performed daily pt assessment, including laboratory and diagnostic test results, presented pt information and plan of care during daily rounds; evaluated pt changes in condition and instituted therapies, medications, and consultations. Developed discharge plan. Daily MD consultation	> 18 y/o with tracheostomy Admitted to neuro unit after laminectomy or for care of intracerebral hemorrhage or hydrocephalus or for care of subarachnoid hemorrhage or brain tumor, with or without craniotomy Urban, academic medical center-inpatient Unknown insurance	Mortality Length of stay Duration ventilation	High (5)

Schultz, 1994 ⁴⁴	NNP and neonatologist (111) Resident MD and neonatologist (129)	Evaluation of the effectiveness of NNP in providing direct day-to-day care to infants in Level III NICU compared to resident MDs. NNPs completed admission history, physical examination, and psychosocial assessment; developed medical and nursing plans; prescribed medications; performed procedures; ordered and interpreted labs; responded to acute changes in condition Daily MD consultation	Infants admitted to transitional care unit Urban, academic medical center-inpatient Unknown insurance	Length of stay ^a Hospitalization	High (6)
Varughese, 2006 ⁵⁶	NP and MD anesthesiologist (77) MD anesthesiologist alone (20)	Evaluated the effectiveness of using NPs rather than MD anesthesiologists to complete preoperative evaluations Daily MD consultation	1509 children between 1 mo and 18 y/o scheduled for outpatient surgery Urban, outpatient surgery of specialty hospital Commercial insurance	Satisfaction	Low (2)

RCT = randomized controlled trial; Pt = patient; NP = nurse practitioner; MD = physician; PCP = primary care provider; CAD = coronary artery disease; LDL-C = low density lipoprotein-cholesterol; HCL-C = high density lipoprotein-cholesterol; BP = blood pressure; GNP = geriatric nurse practitioner; y/o = year old; VAMC = Veterans Administration Medical Center; ADL = activities of daily living; ESRD = end-stage renal disease; SF = short form; DRG = diagnosis related group; IADL = instrumental activities of daily living; SOM = school of medicine; SON = school of nursing; DM = diabetes mellitus; HTN = hypertension; HbA1C = glycosylated hemoglobin; DM2 = diabetes mellitus type 2; NIDDM = non-insulin dependent diabetes mellitus; ICU = intensive care unit; NNP = neonatal nurse practitioner; PNP = pediatric nurse practitioner; CHF = congestive heart failure; ACNP = acute care nurse practitioner; MICU = medical intensive care unit; NICU = neonatal intensive care unit; AMI = acute myocardial infarction; CVICU = cardiovascular intensive care unit; GNP = geriatric nurse practitioner; PA = physician assistant; WHNP = women's health nurse practitioner.

^a Favors NP.

^b Favors MD.