# The physician assistants and nurse practitioners in the Netherlands: a solution for healthcare

Geert van den Brink

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# The physician assistants and nurse practitioners in the Netherlands: a solution for healthcare

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# 1

# Introduction

## Changing healthcare landscape

Healthcare service delivery across the world faces several challenges. First and foremost challenge is how to keep healthcare affordable in the face of increasing demand. A second challenge is how to keep healthcare accessible in underserved areas, across all medical domains, and for all people. Inequality in care is a global problem that requires more and greater attention from all healthcare systems (1). Yetim and colleagues (2020) have identified some of the predominant factors that increases healthcare expenses; an aging population, increasing prevalence of chronic diseases, technological improvements, changes in health insurance, regulations, competition, and income levels (2). Furthermore, costs are determined by how the government finances healthcare and socioeconomic factors such as education level and the degree of prosperity. According to Yetim and colleagues (2020) health expenditures will continue to rise, but improvements in efficiency in the delivery of services could help offset costs (2).

A third challenge is whether enough healthcare professionals are available to deliver the needed care and whether such trained professionals will remain in healthcare for a career. Several variables are at work that compound this provider scarcity problem (3). These include an aging population, more available treatment strategies, and a maturing workforce leading to a tighter labor market. The results compound the difficulties in retaining young healthcare professionals. Furthermore, as more patients endure formerly fatal diseases, this survivability increases the demand for chronic disease management. This in turn affects the number of health professionals required to provide needed services (4).

## The Physician Assistant (PA) and the Nurse Practitioner (NP)

To meet the healthcare delivery challenges of demand exceeding supply, several initiatives have emerged since the new millennium. One strategy in particular is the introduction of Nurse Practitioners (NP) and Physician Assistants/Associates (PA), or PA-like professionals such as Assistant Medical Officers and Clinical Officers. Both have been adopted in over eighteen countries as a strategy to meet the growing demand and reduce medical staff shortages and workload (5-8).

The first education programs for NPs and PAs were developed in the United States in the mid-1960s. A half-century after their introduction, the evidence of their utility and benefit to society are being found worldwide. In the growing investigation of their usefulness to society, the quality of patient care has been assessed as equal to the care provided by doctors (9)(10). At the same time, the introduction of these professions contributes to the reduction of the physician shortage and the mitigation of work pressure (8)(11)(12).

The Dutch PA and NP education system is unique and differs from other programs globally. Within this system it is possible to deepen one's knowledge beginning with holding a bachelor's degree and then moving up hierarchically through a master's degree program. The student not only matriculates, but in the education process applies acquired competencies in direct patient care. This system remains an attractive option for many candidates. As a result, Dutch healthcare professionals can continue working in direct patient care and not having to disband their original employment (3)(23).

## Development of the PA and NP in the Netherlands

The introduction of the PA and NP in the Dutch healthcare system was part of an effort to contribute to medical capacity at the same time providing a favourable redistribution of tasks (3)(13-15). The first Master Advanced Nursing Practice (MANP) and Master Physician Assistant (MPA) programs started in The Netherlands in 1997 and 2002, respectively (13). Both programs have a dual character in which the students develop competencies through an academic program combined with learning and working in practice. Upon completing the program, PAs and NPs are granted a Master of Science (MSc) degree, since 2016. Both professions are protected by law and lead to full practice qualifications (16). Despite many similarities between PAs and NPs, there are differences in which both disciplines are deployed in the Dutch healthcare system. NPs usually treat patients with a

diagnosed disease and combine medical and nursing interventions. The PA usually works within a medical specialty, sees common complaints within that specialty, makes medical diagnoses, and performs medical procedures (10). For both professionals, the health insurer reimburses the treatment without a physician's intervention (17).

As of 2022, there are ten MANP and five MPA programs, each funded by the Ministry of Education and Health of the Dutch government. Each produces a graduate level trained clinician after respectively two years and 2,5 years of education (18)(19). The Dutch system is unique by aligning the demand from the labor market with the supply of these professionals (20). The annual number of seats for NP and PA matriculants approached 800 in 2021 (21). One of the advantages of this system is that there is no financial impediment for the student to return to study; the student maintains their former income.

The workforce of the Dutch PA professional is relatively young, with an average age of 43 years and the majority (73%) are women. Most PAs (78%) work in hospitals and outpatient clinics, with about 10% in primary care offices (22)(15). For NPs, the average age is 49 years, and the vast majority are women (87%). A plurality of NPs (45%) work in hospitals and outpatient clinics, 24% in elderly care, and 6% in primary care (23).

The census of NPs and PAs in the Netherlands is growing and in 2022 there were 1,651 PAs and 4,861 NPs (24)(25). They are employed throughout the healthcare system and work in almost all healthcare sectors and diversity of medical specializations. PAs and NPs perform medical tasks previously performed exclusively by physicians (3).

In 2004, NPs and PAs were granted the authority to perform a broad range of medical procedures independently, initiate a diagnostic test, and prescribe medications appropriate within their field of expertise (e.g., 'scope of practice') (26). Direct patient care activities by PAs and NPs are reimbursed by Dutch health insurance companies. Thus, the NP and PA have full practice authority and, at the same time, perform their work in collaboration with physicians. How the use of the PA or NP influences the improvement of the working life of fellow caregivers remains to be further researched.

## State of the art evidence NPs and PAs

Several international studies have documented the contribution of NPs and PAs to the quality of care provided to the individual patient, the contribution to health improvement at the population level, and

the contribution to cost-effectiveness. Besides empirical studies, several systematic reviews have been published in the last decade (10-12)(27)(28).

The World Health Organization (WHO) describes the quadruple aim as helping to optimize health system performance (29). WHO proposes that health care institutions simultaneously pursue four dimensions of performance: improving the health of populations, enhancing the patient experience of care, reducing the per capita cost of health care, and improving the work-life of health care clinicians and staff (30). The Quadruple Aim, adapted from the Triple Aim, was suggested as a framework to optimize healthcare system performance (30). The framework encompasses improving population health and patient experience, reducing costs and healthcare team well-being. We used this framework to synthesize the evidence of the implementation of NPs and PAs, which is reported according to these aims.

**Population health**

The first aim is the improvement of population health, based on patients enrolled or defined because of certain characteristics they share or based on a common need from demographic or geographic standpoint (31). Examples of interventions are preventative services, routine disease screenings, disease-specific outcomes, patient-reported outcomes, self-care skills adherence to care, mortality, and process of care (32). The literature addressing this first aim was systematically reviewed, and for PAs, the outcomes were equal or better when compared to physicians (9)(33)(34). For NPs, the findings were much the same (35)(36). There were no statistically significant differences between NPs and PAs in primary care settings compared to primary care physicians (11)(36-39).

**Patient experience**

The second aim concerns patient satisfaction and health-related quality of life. Kartha and colleagues (2014) examined PA and NP care in 118 acute care hospitals and found that in half of the Veterans Health Administration (VHA) hospitals, inpatient medicine services with broad, yet similar, scopes of practice an NP or PA was deployed. There were few differences between their roles and perceptions of care with similar size of practice (40). Everett and colleagues (2016) examined the care by PAs and NPs and found numerous situations where the outcomes of care were consistent with that provided by physicians (38)(41).

### Costs of care

The third aim concerns the costs of service and delivery of care. The literature was systematically reviewed, and for PAs, the findings were the same for PAs compared to physicians (9). For NPs, the results were much the same (35)(39). Martin-Misener and colleagues (2015) undertook a systematic review to determine the cost-effectiveness of NPs delivering primary care and specialized ambulatory care. They found that NPs in ambulatory care have equivalent or better outcomes of care when compared to physicians and were cost-effective favorably (27). One of the first reviews was done by Laurant and colleagues in 2005 and updated in 2018, exploring the impact, globally, of NPs on healthcare service delivery in primary care. The authors concluded that cost savings depended on the context of care and the specific nature of their role – whether it was a complement to traditional physician services or as substitutes (10).

### Healthcare team well-being

The fourth objective is essentially all the elements that influence caregivers' working conditions and job satisfaction in a healthcare system. How the use of the PA or NP influences the improvement of the working life of caregivers has not been intensively researched.

## State of the art evidence NP and PA in the Netherlands

In the Netherlands, studies have been underway, beginning with the introduction of PAs and NPs early in the new century. For the most part, research has been undertaken in many healthcare sectors that employ PAs and NPs either separately or together. We report the results according to the Quadruple Aim Framework.

### Population health

Little research has been done in the Dutch healthcare system into improving public health in relation to the use of the PA. However, the effects of the NP within patient populations have been the subject of several studies. The results of these studies is the same, an increasing quality and continuity of care occurs when an NP is part of the patient care system (42-45). One of the first empirical studies was carried out by Dierick- van Daele et al. (2011). She researched the NPs' employment in general practices. The NP treated patients with common conditions and no significant differences in outcome or process measures when compared to the GP (46). These results were found against the context that the NP treated only common

and less complex cases and that the GP had an important supervisory role. Since this study was published the scope of practice has evolved, and the Dutch NP now has full practice authority.

**Patient experiences**

Van der Biezen et al. (2016 ) evaluated the employment of NPs in out-of-hours primary care services and the employment in primary care offices. The intervention involved the substitution of some GPs with NPs. One outcome was that care provided by NPs is more or less the same as care provided by GPs (44). Meijer et al. (2017) examined whether patients are satisfied with the care provided by a PA instead of a general practitioner (47). This study found that Dutch patients appear to be as satisfied with the care received by PAs as GPs. Timmermans et al. (2017) researched the employment of the PAs on the ward compared with wards employing only MDs or wards with residents supervised by MDs. One conclusion was an improvement in patient quality of life in PA-led wards (48). De Bruijn et al. (2018) evaluated the effects of awarding legal full practice authority (FPA) to NPs and PAs. Care processes were organized more efficiently by granting full practice authority to NPs and PAs, and medical tasks were performed qualitatively (26). Lovink et al (2019) concluded in their study that NPs and PA add to good patient care by their contributions to quality of health care, provision of patient-centered care, and strengthening of the care team despite the variation in tasks and responsibilities (45). The introduction of these professionals also changed the role of the elderly care physicians.

**Costs of care**

The cost-effectiveness of NPs was researched by Dierick- van Daele et al. (2011). They found that the direct costs of consultations in GP practices performed by NPs were lower (46). Also van der Biezen et al. (2017), included the costs effectiveness during out of hours primary care services. She found that NPs can make a valuable and efficient contribution to patient care during out-of-hours (49). No systematic studies on the cost-effectiveness of PA deployment have been undertaken within the Dutch health care system. However, Kouwen et al. (2015) showed that PA and NP employment contributed to cost-effectiveness of service delivery in a variety of settings (50).

**Healthcare team well-being**

Concerning the fourth aim, improving the work-life of health care clinicians and staff, several studies have been undertaken with different

outcome parameters. The added skills of NPs and PAs have reduced the physician's workload in the out-of-office service in both direct and indirect patient care (44). Lovink et al. (2019) have described in their study that the role of the elderly care physician changed after the introduction of an NP or PA into a more coordinating and supporting role (45). The job satisfaction of the NP and PA themselves has been examined more extensively and found generally high across several healthcare settings (51).

Alumni of both career paths remain employed in their profession for a considerable period; 80% of PA graduates are still working as PAs 10 years after graduation. For the NP, the figure is 88%. Thus, the opportunity cost of the government's education investment has been a societal benefit (23). This development contributes to making the healthcare industry an attractive place to work (3).

## Scientific gap

PAs and NPs are viewed as a solution for future healthcare challenges and can play an essential role in the Quadruple Aim in Dutch healthcare systems. They not only contribute to advancing quality medical care but provide an attractive career aspiration for bachelor-trained health professionals to advance their care skills. This education model contributes to the allure of the healthcare industry as a viable workplace for school leavers (20)(22)(23).

Although the employment of PAs and NPs has been studied in several countries including the Netherlands, the actual contribution of the PA and NP to the Dutch healthcare system needs more clarification (50). With a crystallized scope of practice combined with full practice authority, along with the visible activities of the NP and PA in the health services research, the effects can determine more accurately patient care quality, cost reduction and the contribution to job satisfaction. These factors concern the effects of both their in-hospital employment care and primary healthcare.

However, not all aspects of the contribution of the PA and NP pertain to healthcare regarding production, costs, and benefits. It is the added tasks, and the contribution to the capacity and sustainable employability of the medical staff that have need to be researched next.

## Aim of this thesis

The central aim of this thesis was to determine the contributions of NPs and PAs in the Dutch healthcare system. More specifically, a description

of the tasks performed by the NP and PA, as well as the effects on quality, continuity, costs, and job satisfaction.

The central research questions that provide insight into the contribution of NP and PA employment in healthcare are:

- What is the various patient-related task areas of the PA and NP in-hospital services and clinics?
- What effects of PA employment have been described in different settings?
- What is the cost-effectiveness of the PA in the Dutch hospital wards compared with physicians?
- What are the employment effects of the PA and NP in Dutch general practices on the workload and job satisfaction of professionals?
- What is the return on investment of the PA and NP in Dutch general practices?

## Outline of this thesis

**Chapter 2** describes the results of a systematic review on the economics of PA employment. In total, 42 articles were included, and data was extracted about quality of care, the process of care, care provider outcomes, accessibility of care, and costs of care.

**Chapter 3** describes an activity analysis of Dutch hospital-based PAs and NPs. A descriptive, non-experimental research method design was used to collect and analyze both quantitative and qualitative data about the type of tasks performed by a PA or NP. Fifteen medical departments across four hospitals participated. The different tasks performed by PAs and NPs in hospitals were categorized into patient and non-patient-related tasks, how the collaboration was organized, and the value contributed by the PA and NP.

**Chapter 4** presents a multicenter, matched-controlled study about the cost-effectiveness, quality, and safety of hospital ward care by a PA-based team compared to a team with physicians only in Dutch hospitals.

**Chapter 5** describes the effects of PA and NP employment on the workload for GPs and the return of investment in four different types of GP practices in the Netherlands. A mixed-methods approach, exploratory study, was used to retrospectively examine general practices employed by a PA or

NP. Electronic data from the practice information systems were combined with interviews. In addition, to examine generalizability, physicians from 13 practices representative of Dutch primary healthcare participated in a focus group to comment on the findings.

**Chapter 6** presents the main findings of this thesis and discusses the implications of the results. In addition, the implications for clinical practice, education, and future research are formulated.

The thesis concludes with a summary in English and in Dutch.

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# 2

# The Cost-Effectiveness of Physician Assistants/Associates: A Systematic Review of International Evidence

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## Abstract

**Background:** The global utilization of the physician assistant/associate (PA) is growing. Their increasing presence is in response to the rising demands of demographic changes, new developments in healthcare, and physician shortages. While PAs are present on four continents, the evidence of whether their employment contributes to more efficient healthcare has not been assessed in the aggregate. We undertook a systematic review of the literature on PA cost-effectiveness as compared to physicians. Cost-effectiveness was operationalized as quality, accessibility, and the cost of care.

**Methods and Findings:** Literature to June 2021 was searched across five biomedical databases and filtered for eligibility. Publications that met the inclusion criteria were categorized by date, country, design, and results by three researchers independently. All studies were screened with the Risk of Bias in Non-randomised Studies – of Interventions (ROBIN-I) tool. The literature search produced 4,855 titles, and after applying criteria, 39 studies met inclusion (34 North America, 4 Europe, 1 Africa). Ten studies had a prospective design, and 29 were retrospective. Four studies were assessed as biased in results reporting. While most studies included a small number of PAs, five studies were national in origin and assessed the employment of a few hundred PAs and their care of thousands of patients. In 34 studies, the PA was employed as a substitute for traditional physician services, and in five studies, the PA was employed in a complementary role. The quality of care delivered by a PA was comparable to a physician's care in 15 studies, and in 18 studies, the quality of care exceeded that of a physician. In total, 29 studies showed that both labor and resource costs were lower when the PA delivered the care than when the physician delivered the care.

**Conclusions:** Most of the studies were of good methodological quality, and the results point in the same direction; PAs delivered the same or better care outcomes as physicians with the same or less cost of care. Sometimes this efficiency was due to their reduced labor cost and sometimes because they were more effective as producers of care and activity.

**Key Words:** Medical Care Organization; Physician Assistant; Physician Associate; Quality of Care, Accessibility; Costs; Substitution; Complement, Systematic Review

## Introduction

Healthcare systems across the globe face several challenges to meet patient demand and deliver high-quality healthcare. The challenges are primarily population growth, increasing chronically ill patients, rising patient expectations, and longevity (1). At the same time, the supply of physicians is limited in many countries, leading to medical labor shortages (2).

The gap between physician capacity and patient demand is expanding and requires a change to the medical workforce. At least 18 countries have introduced the Physician Assistant/Associate (PA) as a solution (3). These health professionals perform various medical and surgical services, and their numbers are growing across multiple settings.

In labor economics, if a PA replicates the activities of a physician, then that is a 'physician substitute' (4). If, on the other hand, the PA improves the throughput in the medical process, then the PA is a 'complement' of physician services (5)(6). In most instances, the employment of the PA was the result of a medical shortage or a need to improve the quality of the medical service.

Because of their increasing utilization worldwide, understanding the economic value has become essential to their utilization. To date, no published systematic reviews have examined the cost-effectiveness of the PA. Therefore, the aim of this project was to review the effects of quality of care, accessibility of care, and costs of physician substitution by PAs in a variety of settings. This was operationalized as a research question: What is the cost-effectiveness of PAs compared to physician services?

## Methods

A systematic review was undertaken using the reporting criteria developed at the University of York (7). The protocol outlined the overview, objectives, aims, operational definitions, search strategy, inclusion/exclusion criteria, and quality appraisal methods.

### Search strategy

The following international bibliographies were systematically searched: PubMed, Web of Science core collection (WoS), CINAHL (with full-text EBSCO), Embase-Ovid, and The Cochrane Library. A detailed search strategy was developed in consultation with two experts; a librarian experienced in systematic reviews and a health workforce researcher.

The search strategy used PubMed as a format and then adapted it to the other database results. Searches were performed in 2021 and spanned all published studies through June 2021. Subsequently, the included articles and references were examined using a backward and forward snowball citation search method in Web of Science and Google Scholar to identify relevant other studies.

**Inclusion and exclusion criteria**

The literature search included all original empirical research studies on PAs with a comparative quantitative evaluation design written in English or Dutch. There were no date restrictions on publications. Both 'Physician Assistant' and 'Physician Associate' were included in the review, as they have a similar scope of practice. In addition, studies of 'Clinical Assistants' working in South Africa were included because their role is similar to, and modelled after, the PA (8)(9).

Studies that encompassed nurse practitioners (NPs) and PAs but the provider type was missing were excluded. We omitted findings in which PAs were still in training, or the setting had an educational purpose. Articles were excluded when the outcome of care did not fit the protocol or where the care outcome of PAs was not compared to those of physicians.

**Study selection**

Citations from the systematic literature search were uploaded to the screening process to Rayyan QCRI, a systematic review computer-based application system (10). Two of three reviewers screened all articles independently (GvdB, AvV, RSH) and were blinded to the others' findings. Abstracts were vetted using the inclusion/exclusion criteria, and ineligible reports were omitted. Those abstracts receiving conflicting votes were discussed, and after reading the text, consensus for inclusion or exclusion was reached. Articles were rejected when a PA and NP were included in the aggregate but not separated as two providers (and not compared one to the other).

**Data collection, analysis, and synthesis**

Two reviewers (GvdB, RSH), acting independently, extracted data from each article using a structured form and blinded to the other's findings. In addition, five corresponding authors of a candidate study were asked for clarifying information, such as the number of PAs in the project or how many clinics were involved.

Each article was assessed for quality using the Risk of Bias in Non-Randomised Studies-of Interventions (ROBIN-I) tool. The ROBIN-I instrument was developed for healthcare evaluation with potential biases in non-randomized studies that compare the effects of two or more interventions (11). Assessing the risk of bias resulted in a summary score for every research domain ranging from 0 when there was no information; 1 for low risk of bias; 2 for moderate risk of bias; 3 for a significant risk of bias; and 4 for risk of bias was critical. When there was no information, the score was assessed as a serious risk of bias. These different scores per domain result in an overall risk of bias score from 1 to 4 (low bias to the critical risk of bias).

The first 19 data-extracted articles were reviewed by two reviewers independently, and a 97% agreement was reached for all criteria. Based on the high degree of agreement, the remaining articles were assessed by one reviewer (GvdB). The different scores per domain resulted in an overall risk of bias from 1 to 4 (low to critical risk of bias).

Extracted data were organized as:

1. General information (i.e., author, year of publication, country, setting).
2. Study design, follow-up period, research question.
3. Description of the intervention and whether the PA acted as a labor substitute or complement to a physician.

Papers that draw on the same study were extracted and analyzed as one study. The following outcomes representing cost-effectiveness were assessed:

**Quality of care**

The quality measurement of healthcare is based on the Donabedian model (12). Metrics of quality of care are outcomes of care and the process of care. Evaluating the quality of care underpins the measurement for organizational improvement and is a primary focus of health services research (13).

*Patient outcomes*: these include morbidity, mortality, patient satisfaction, quality of life, health status, knowledge, and preference for a physician or PA.

*Process of care outcomes:* patient safety, quality of healthcare, adherence/compliance to guidelines or protocols, healthcare activities (examination, provision of advice, etc.), and referrals to other healthcare services.

*Care provider (physician, PA) outcomes:* includes workload (objective and subjective) and job satisfaction.

### Accessibility of care

The focus on the accessibility of care is the employment effect of the PA on a patient entering the healthcare system. A component of access is the patient's waiting time to be seen for a medical or surgical condition.

### Costs of care

Cost of care is the expenditures or utilization of resources in the delivery of healthcare services.

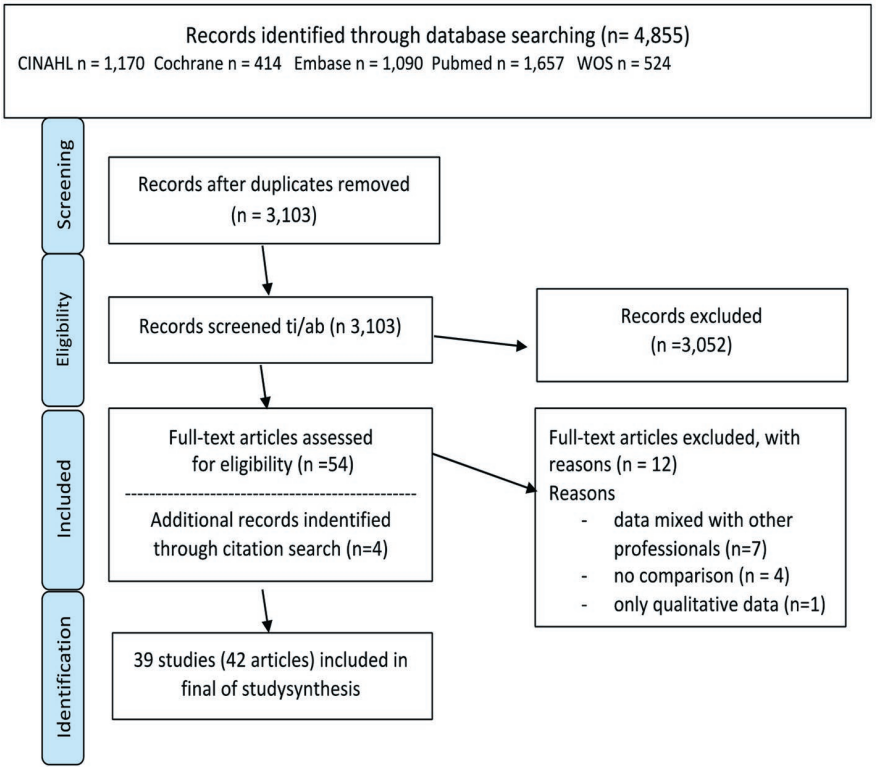
## Results

In total, there were 4,855 titles of abstracts, papers, or reports identified by searching the bibliographies. After de-duplicating, 3,103 titles remained and were screened on title and abstract. The remaining records were assessed for the availability of a full report or article that was peer-reviewed prior to publication. Many titles were poster or presentation abstracts without sufficient details on the methods and analysis and were excluded. After this screening, 54 articles remained, resulting in discussion and five instances of communicating with the author for more information. As a result of the final filtering process and discussion of each paper, a total of 42 articles emerged from the sorting process for final inclusion. The literature retrieval and study selection are shown in Figure 1.

### Characteristics of included studies

The included articles (N=42) spanned the years 1977–2021. The national origins of the articles were: North America (n=34), Europe (n=7), and Africa (n=1). Over 500 PAs were involved or observed, and their numbers ranged from 1 to 443 (almost 50% of the studies reporting five or fewer). The quantity of PAs in the aggregate is unknown since the number was not consistently stated, and follow-up correspondence with authors did not often reveal more information. Study designs ranged from retrospective cohort studies (n=29) to prospective studies (n=10 – including one time-motion study).

**Figure 1.** Literature retrieval and study selection




Eight studies described the introduction of a PA for a single procedure (17-24). In the remainder of the studies, the PA was assigned broad medical tasks. In five studies, the introduction of the PA was accompanied by organizational changes or the adaptation of various work processes (16)(17)(25-27). Changes included extra training or expanded time per patient, dedication to some procedure, more supervision by senior medical staff, or a combination of factors.

Ten studies occurred in an emergency department/acute care setting (14-16)(28-34). Eight were in the Department of Veterans Affairs, Veterans Health Administration (a national setting of 170 large medical centers and 1,400 outpatient clinics in the USA) (19)(35-41). The remaining studies were in different settings in hospitals.

The characteristics of included studies are listed in Table 1.

**Table 1.** Characteristics

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Althausen** 2013 (USA) (19) | Hospital-based Emergency Department. | 2 | **Design:** Retrospective cohort case series assessed the presence or absence of PA. Charts reviewed were of adult patients presenting to an ED in 2005.<br>**Question:** What is the true impact of hospital-based PAs on orthopedic trauma care at a level II community hospital?<br>**Intervention:** 310 patients with orthopedic injuries who received care from a PA.<br>**Control:** 687 patients with orthopedic injuries who received care from an MD. |
| **Arnopolin** 2000 (USA) (29) | Hospital-based Emergency Department | 5 | **Design:** Retrospective cohort study. Comparison of PAs and physicians (5 PAs and 25 MDs).<br>**Question:** Are PAs an appropriate option for providing services rendered by physicians in an urban urgent-care facility?<br>**Intervention:** PA was the sole provider for patient encounters; 14 diagnostic groups based on the billed ICD-9 codes (4,256 patients).<br>**Control:** MDs saw the same type of patients (5,345). |
| **Capstack** 2016 (USA) (26) | Community Hospital Inpatients – Internal Medicine | 6 | **Design:** Retrospective cohort study.<br>**Question:** Can a physician-PA hospital staffed model achieve similar clinical outcomes for inpatients in a community hospital compared to a conventional physician hospitalist staffed model?<br>**Intervention:** A high PA-to physician ratio model ("expanded PA"), with 3 physicians/3 PAs and the PAs rounding on 14 patients a day (35.7% of all visits – 6,612 patients.<br>**Control:** Low PA-to-physician ratio model ("conventional"), with nine physicians/ two PAs and the PAs assessing nine patients a day (5.9% of all visits – 10,352 patients. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Costa** 2013 (USA) (17) | Hospital: Transplant Surgery | 1 | **Design:** Retrospective cohort study – review of 287 consecutive lung procurements performed by either a PA or MD fellow – spanning 5 years.<br>**Question:** Is a PA a cost-effective, reproducible, and safe alternative for surgical fellows and attending surgeons as the lead donor surgeon for consecutive lung procurements?<br>**Intervention:** A transplant-trained PA is the lead donor surgeon for consecutive lung procurements. (197 cases)<br>**Control:** Transplant (MD)-fellows served as senior donor surgeons. (90 cases) |
| **Decloe** 2015 (Canada) (42) | Hospital: Infectious Disease Department | 1 | **Design:** Retrospective case-control study.<br>**Question:** Does introducing a PA infectious disease consulting service affect inpatient length of stay (LOS) and mortality rates?<br>**Intervention:** The introduction of a PA in a large urban community hospital in Canada (2010 to 2011) in the infectious disease consult service (3,386 patients).<br>**Control:** The two years of MD use and LOS data before the introduction of the PA (13,493 patients). |
| **De la Roche** 2021 (Canada) (30) | Hospital: Emergency Department | 1 | **Design:** Retrospective cohort study<br>**Question:** What is the effect of a PA working in a hospital emergency department (ED) on the overall performance of the ED?<br>**Intervention:** With the introduction of the PA in the ED, the PA saw 9,701 patients with the family practitioner (PA group).<br>**Control:** 10,776 patients who visit the ED are seen by a family practitioner (MD-group). |
| **DeMots** 1987 (USA) (33) | Hospital: Coronary angiography laboratory | 1 | **Design:** Prospective cohort study.<br>**Question:** Is it safe and time-saving when a PA performs cardiac catheterization?<br>**Intervention:** 150 cardiac catheterizations performed by a PA.<br>**Control:** 150 cardiac catheterization performed by 4 cardiology fellows. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Dhuper** 2009 (USA) (43) | Hospital, Community General medical floors (ICU, coronary care unit, subacute/ intermediate care unit, and telemetry unit). | 23 | **Design:** Prospective, Before – After-study, retrospective case-controlled.<br>**Question:** What effects resulted from replacing medical residents with PAs as hospitalists on patient outcomes in a community hospital?<br>**Intervention:** Care delivered by PAs in a general hospital setting. The PAs functioned as the house staff (5,508 patients).<br>**Control:** Care delivered by residents (MDs) in a general hospital setting (5,458 patients). |
| **Drennan** 2014 (25) & **de Lusignan** 2016 (England) (44) | General practitioner offices | 4 | **Design:** An observational study based on prospective data.<br>**Question:** What is the quality of patient consultation outcomes, and what are the costs of same-day consultations (patient encounters) by PAs compared to GPs? What is the quality of the patient consultation of physician associates in comparison to that of general practitioners?<br>**Intervention:** PAs in GP offices saw all patient encounters for same-day (urgent) appointments (932 patients).<br>**Control:** GP's office seeing all patients encounters for same-day (urgent) appointments (1,154 patients). |
| **Everett** 2019 (USA) (45) | Veterans Affairs Outpatient clinic | Unknown | **Design:** Retrospective cohort study; data extracted from the Veterans Health Administration electronic health record.<br>**Question:** Are there differences in diabetes outcomes between patients (n=609,668) with different types of primary and supplemental providers (physicians, PAs and NPs?)<br>**Intervention:** Care delivered by PA (n=24,250) as primary care provider (PCP) and care delivered by PA with physician (n=14,342).<br>**Control:** Care delivered by:<br>Physician as PCP (n=408,009) or<br>Physician as PCP plus NP supplemental (n=39,861) or<br>Physician as PCP plus PA supplemental (n=24,692).<br>NP as (n=66,042) or by NP as PCP with physician supplemental (n=32472) |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Faza** 018 (USA) (35) | Veterans Affairs Medical Centers (multiple sites) | 409 | **Design:** Retrospective; regression analyses of patients with diabetes or cardio-vascular disease (CVD) with a primary care visit in 130 Veterans Affairs Medical Centers to assess the association between provider type and effectiveness of resource use.<br>**Question:** What is the effectiveness of CVD and diabetes care delivered by PAs and NPs in a primary care setting?<br>**Intervention:** Care delivered by PAs (N=409)<br>**Control:** Care provided by NPs (N=1,325). |
| **Fejleh** 2020 (USA) (19) | Veterans Affairs Medical Center (St. Louis, MO), gastro-enterology clinic | 5 | **Design:** Retrospective cohort study randomly assigned colonoscopy to PA or MD in a single-center gastroenterology suite.<br>**Question:** What are the differences in quality measures of PAs and MDs in screening colonoscopies?<br>**Intervention:** Quality of 169 procedures by 5 gastroenterology PAs.<br>**Control:** Quality of 428 procedures by 39 MD (Gastroenterologist (7) and fellows (32)) |
| **Fung** 2020 (USA) (34) | Rural hospital, intensive care unit | 1 | **Design:** Retrospective cohort study.<br>**Question:** What are the effects of adding a PA to the internist-ICU team on mortality, readmission, ICU and hospital LOS, Hospital Intensity Group weighting, and quality of chart documentation?<br>**Intervention:** Adding a PA to the internist ICU team (132 patients).<br>**Control:** An internist ICU team without a PA (136 patients). |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Glotzbecker** 2013 (USA) (46) | Inpatient academic medical center oncology unit | 12 | **Design:** Retrospective cohort study; data collected on all patients with acute myelogenous leukemia (AML) admitted to the house officer or PA working on the hematologic malignancy service for reinduction of chemotherapy from 2008 through 2012.<br>**Question:** What is the quality of AML care provided by an oncology PA compared with an oncology MD?<br>**Intervention:** 48 patients with AML (50.5%) admitted to the PA service.<br>**Control:** 47 patients with AML (49.5%) were admitted to the physicians in training (MD house officers). |
| **Goldman** 2004 (USA) (21) | Outpatient surgical abortion services | 6 | **Design:** Prospective cohort study of women undergoing a surgically induced abortion. Ninety-one percent of eligible women (1,363) were enrolled.<br>**Question:** What are the complications after surgical abortion procedures performed at two clinics? Also addressed access to abortion services, patient's and practitioner's care experiences, and practitioners' conformance to clinical guidelines.<br>**Intervention:** One hospital at which PAs performed surgical abortions.<br>**Control:** One hospital at which physicians performed abortions. |
| **Grzybicki** 2002 (USA) (47) | Family/general medicine practice | 1 | **Design:** Retrospective mixed methods, quantitative study concerning the daily activities and the economic effects of employing a PA instead of an MD (13,000 visits).<br>**Question:** What is the economic benefit of PA in a solo medical practice?<br>**Intervention:** Employment of one PA.<br>**Control:** Published national statistics on MD employment. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Halter** 2020 (England) (31) | Emergency Departments (3) | 6 | **Design:** Retrospective cohort study: charts reviewed and interviews (mixed methods) assessed the clinical adequacy and quality of care.<br>**Question:** Compared to MDs, what is the rate of unplanned return to the emergency departments (EDs) when managed by PAs?<br>**Intervention:** Six PAs working in 3 EDs (1,129 patients).<br>**Control:** 40 foundation doctors (MBBS year 2) working in 3 EDs (2,068 patients). |
| **Hooker** 2002 (USA) (48) | Large multi-specialty ambulatory health maintenance organization (HMO) | 43 | **Design:** Retrospective, cost-benefit analysis – comparison of providers (PAs or MDs) managed episodes of care and the use of resources for that care. Random selection of patients to PA or MD for an acute condition. No cross-over or shared care. Use of resources was assigned institutional costs.<br>**Question:** Do PAs negate their cost-effectiveness by using more resources for an episode of disease?<br>**Intervention:** Eight clinics where an episode of acute care was managed by PAs longitudinally.<br>**Control:** Eight clinics where an episode of acute care was managed by MDs longitudinally. |
| **Hooker** 2004 (USA) (49) | Medium size occupational & environmental medicine (OEM) clinic (8 sites) | 12 | **Design:** Retrospective, cost-benefit analysis – comparison of cost of care between MD and PA spanning one year.<br>**Question:** How do PAs & MDs in OEM compare in the outcomes of care?<br>**Intervention:** Clinics where an episode of acute care was managed by 12 PAs longitudinally.<br>**Control:** Clinics where an episode of acute care was managed by 24 MDs longitudinally. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Jackson** 2018 (USA) (36) | Department of Veteran Affairs primary care facilities (multiple sites) | 443 | **Design:** Retrospective cohort study. The relationship between the PCP (primary care provider the patient most often visited) and the continuous and dichotomous control of hemoglobin A1c, systolic blood pressure, and low-density lipoprotein cholesterol was examined based on the mean of measurements.<br>**Question:** What are the differences in chronic disease outcomes among patients managed by physicians, NPs, and PAs as PCPs?<br>**Intervention:** Care was provided by 443 PAs (25,352 patients).<br>**Control:** Care for 343,129 patients was delivered by physicians (n=3,487) and NPs (n=1,445). |
| **Kawar** 2011 (USA) (50) | Hospital Medical Intensive Care Unit | 4 | **Design:** Prospectively Medical Intensive Care Unit (MICU) data on 5,346 patients admitted to a MICU; 3,971 patients admitted to an MD-managed MICU (resident group) and 1,375 to a PA-managed MICU (PA group).<br>**Question:** What are clinical outcome differences between patients admitted to a resident and a PA MICU?<br>**Intervention:** A 16-bed MICU run by a team of four PAs, a critical care MD fellow, and an attending critical care physician.<br>**Control:** A 32-bed MICU run by two teams consists of 4 to 6 second-year internal medicine residents, a critical care MD (fellow), and an attending critical care physician. |
| **Krasuki** 2003 (USA) (22) | Hospital Cardiac Catheterization Lab | 3 | **Design:** Retrospective cohort study.<br>**Question:** Is there a difference in the outcomes of patients undergoing cardiac catheterization procedures by PAs vs MDs?<br>**Intervention:** In total 929 cardiac catheterizations were performed by three supervised PAs.<br>**Control:** MD=4,521 catheterizations performed by 21 different cardiology fellows with similar supervision. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Kuo** 2013 (USA) (51) | Nursing Homes (multiple sites) | Unknown | **Design:** Retrospective cohort study of 12,249 nursing home (NH) residents managed by PAs or MDs. Potentially avoidable hospitalizations and Medicare costs were assessed, ranging from 6–48 months. Three primary care providers managed NH care (PCPs): 5% PAs, 25% NPs, and 70% MDs.<br>**Question:** Are potentially avoidable hospitalizations of NH residents a function of the percentage of clinical effort their PCP devotes to NH practice?<br>**Intervention:** PAs who worked as the PCP for residents in an NH.<br>**Control:** Physicians who worked as the PCP for residents in an NH. |
| **Malloy** 2021 (USA) (24) | Hospital, surgery | 1 | **Design:** Retrospective cohort study<br>**Question:** What are the indirect costs in training surgical residents by comparing the differences in operative time and procedural charges between a resident and a PA first-assisting adolescent reduction mammaplasty?<br>**Intervention:** The PA (1) with two years of experience was the first assist surgeon involved in 25 operations.<br>**Control:** A range of residents (15 MDs) served as the first assist surgeon in 24 operations. The remaining surgeons were part of an integrated plastic surgery training program. |
| **Morgan** 2008 (USA) (37) | Outpatient clinics: Department of Veterans Affairs: 150 medical centers (national represented data) | Unknown | **Design:** Retrospective cohort study; data extracted from the Medical Expenditure Panel Survey.<br>**Question:** Is PAs substantive inclusion in patient care associated with increased numbers of office visits per patient, adjusting for case-mix differences between patients seen by PAs and physicians?<br>**Intervention:** A group of patients had a substantive portion (30%) of their office-based visits attended solely by a PA (1,762 adults).<br>**Control:** A group of patients group who received only physician care (111,184 adults). |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Morgan** 2019 (USA) (38) | Outpatient clinics: Department of Veterans Affairs: 150 medical centers (national represented data) | 2,806 | **Design:** Retrospective cohort study: data extracted from the Veterans Health Administration electronic health record.<br>**Question:** What are the healthcare use and the total costs of care among 47,236 medically complex patients veterans with diabetes, comparing physician, NP, and PA primary care providers?<br>**Intervention:** Care delivered by PAs as care providers (2,806).<br>**Control:** Care delivered by physicians as a care provider (36,894). |
| **Nestler** 2012 (USA) (15) | Hospital Emergency Department | 1 | **Design:** Prospective, observational cohort controlled before-and-after study design. A total of 724 adult patients were included. Data were extracted from the medical records.<br>**Question:** Does the employment of a PA, acting as a triage liaison provider (TLP), shorten the LoS and reduce the proportion of patients who 'leave without being seen?<br>**Intervention:** Spanning 8 pilot days, a PA TLP was added to the existing staffing (371 patients).<br>**Control:** A total of 8 control days without a TLP (335 patients). |
| **Ngcobo** 2018 (South Africa) (23) | Surgical Clinic | Unknown | **Design:** The retrospective analysis consisted of measuring and comparing the presence of adverse events associated with adult circumcisions.<br>**Question:** Do Clinical Associates (ClinAs) perform circumcisions at a comparable clinical standard as doctors?<br>**Intervention:** 4195 patients operated on by CAs.<br>**Control:** 543 patients operated on by a physician. |
| **Oswanski** 2004 (USA) (32) | Emergency Department (Level 1 Trauma Center) | Unknown | **Design:** Retrospective analysis of patient care for two 6-month segments was at a Level II Trauma Center.<br>**Question:** To assess the quality of patient care during the transition from resident- to PA-assisted trauma program (without residents) and simultaneous comparative support.<br>**Intervention:** 479 patients received care from PAs in a PA-assisted trauma program (without residents) and simultaneous comparative support.<br>**Control:** 293 patients received care from MD resident-assisted trauma program and simultaneous comparative support. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Pavlik** 2017 (USA) (33) | General Community Emergency Department – Pediatric Patients | 8 | **Design:** Prospective cohort study. During a 24-month study period, a total of 10,369 pediatric patients (0 and 6 years) were treated in the ED. Three different treatment groups were defined for the analysis: emergency physicians (EPs) alone, PAs alone, and PAs with consults from emergency physicians (PA & EP).<br>**Question:** What are the 72-hour recidivism rates of PA-managed pediatric patients in a general emergency department?<br>**Intervention:** PAs alone (2,789 patients) and PA & EP (984 patients) treat young children in an emergency department.<br>**Control:** EPs who alone treat young children (293 patients) in an emergency department. |
| **Resnick** 2016 (USA) (18) | Outpatient Oral and Maxillofacial Surgery | 2 | **Design:** Prospective cohort study (before-after) of patients from the Department of Plastic and Oral Surgery at a children's hospital who underwent removal of 4 impacted third molars with intravenous sedation in an outpatient facility. A total of 50 patients, each cohort contained 25 patients.<br>**Question:** What are the time, cost, and complication rates of integrating PAs into the procedural components of an outpatient oral and maxillofacial surgery practice?<br>**Intervention:** Introduction of a PA in the operating team. The PAs obtained procedural consent, provided local anesthesia after adequate intravenous sedation had been delivered, and performed wound closure after removing the third molars by the maxillofacial surgeons.<br>**Control:** A traditional team without PAs. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Roy** 2008 (USA) (52 | Academic Medical Center General medicine | 5 | **Design:** Retrospective cohort study of 5,194 patients on a general medicine service of a 747-bed Academic Medical Center.<br>**Question:** How is the quality and efficiency of patient care of a PA hospitalist service compared with that of traditional MD house staff services?<br>**Intervention:** Patients (992) were admitted to the general medical service on the PA hospitalist service.<br>**Control:** Patients (4,202) were admitted to the general service with a traditional house staff service. |
| **Singh** 2011 (USA) (53) | Academic Medical Center; General Medical Inpatient Care | 2 | **Design:** Retrospective study of 9,681 general medical hospitalizations.<br>**Question:** What are the outcomes of inpatient care provided by a hospitalist-PA model compared with the traditional resident-based model?<br>**Intervention:** Hospitalist-PA model for general medical hospitalizations (2,171 patients).<br>**Control:** Traditional resident-based MD model for general medical hospitalizations (7,510 patients). |
| **Smith** 2020 (USA) (39) | Outpatient clinics: Department of Veterans Affairs: 170 medical centers (national represented data) | 443 | **Design:** Retrospective study of 368,481 adult diabetes patients.<br>**Question:** What are the utilization costs of care by MD, PAs, and NPs?<br>**Intervention:** PA delivered care (25,352 patients).<br>**Control:** MD and NP delivered care (301,361 patients). |
| **Theunissen** 2014 (NL) (16) | Academic Medical Center; Emergency Department | 2 | **Design:** Prospective comparative intervention design.<br>**Question:** Does the use of a PA in an emergency department's fast-track (FT) unit have a favorable effect on waiting times and turnaround times?<br>**Intervention:** The group of 1,280 patients was seen at the FT unit by the PA.<br>**Control:** 1,378 patients were seen at the trauma unit by the trainee surgeon. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Timmermans** 2017 (a, b) (41) (56) & **Bos** 2018 (NL) (55) | Large urban Hospitals (multicenter) | 25 | **Design:** A retrospective, multicenter, matched-controlled study. Patients were assessed for Quality-Adjusted Life Years (QALY). **Question:** What is the cost-effectiveness (cost-utility) of substitution of care from MDs to PAs **Intervention:** MDs and PAs were assigned inpatient care on 17 wards (1,015 patients). **Control:** The traditional model in which only MDs were assigned inpatient care on 17 wards (1,378 patients). |
| **Tompkins** 1977 (USA) (14) | Outpatient clinic for acute respiratory or ear problems | 5 | **Design:** Prospective, Time-Motion Study. **Question:** How effective is the medical care for acute respiratory ill patients provided by physicians and algorithm-assisted PAs and military medical assistants? **Intervention:** PAs provided care by an algorithm and supervision by an MD (2,149 patients). **Control:** One group of patients received care provided by MDs (389 patients). One group of patients received care from algorithm-assisted military medical assistants (3,212 patients). |
| **Van Rhee** 2002 (USA) (54) | A large community teaching hospital Internal medicine | 16 | **Design:** Retrospective cohort study. A total of 5,194 consecutive patients were admitted to the general medical service, including 992 patients on the PA/ hospitalist service and 4,202 patients on a traditional house staff service. **Question:** What is the quality and efficiency of patient care on a PA/hospitalist service compared with traditional house staff services? **Intervention:** A medical service staffed with PAs and supervised by MD hospitalists for inpatient general medicine service of a 747-bed academic medical center. **Control:** Traditional house staff (MD)service. |

| First author and Year of Publication (Country) | Setting | Number of PAs involved | Design |
|---|---|---|---|
| **Yang** 2018 (USA) (40) | Outpatient clinics: Department of Veterans Affairs: 150 medical centers (national represented data) care for diabetic patients | 240 | **Design:** Retrospective cohort study<br>**Question:** What is the quality of the primary care for patients with diabetes mellitus managed by primary care NPs, PAs, or physicians? (19,238 patients)?<br>**Intervention:** Care delivered by PAs (1,367 patients).<br>**Control:** Care delivered by physicians and NPs. (15,050 & 2,821 patients). |

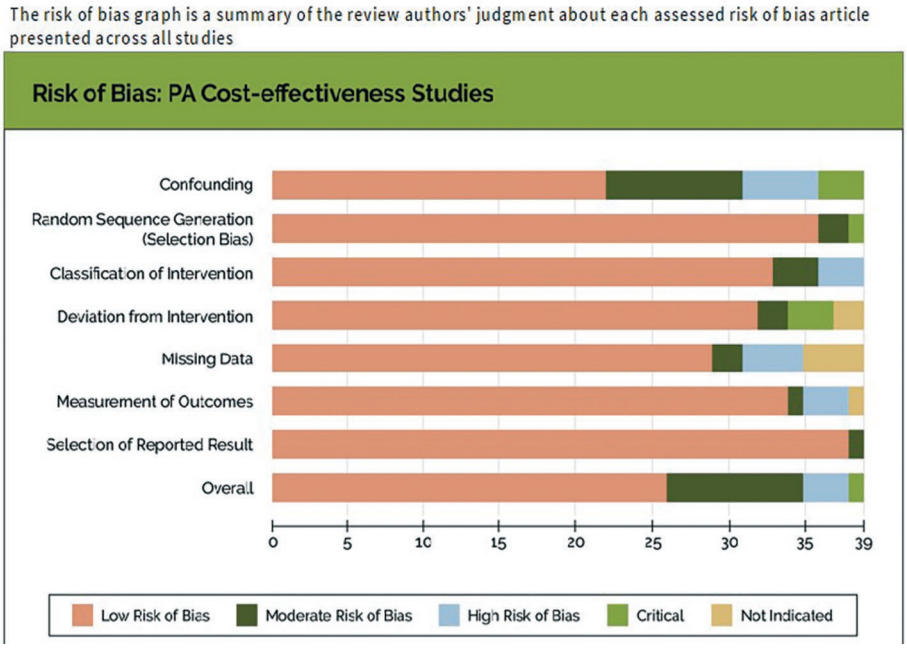
**Abbreviations:** AML: Acute myelogenous leukemia; ED: emergency department; EP: emergency physician; FT: fast track; LoS: Length of Service; MICU: Medical Intensive Care Unit; NL: Netherlands; NPs: nurse practitioners; MDs: medical doctors; PCPs: primary care providers; PAs: physician assistant/associates; QALY: Quality Adjusted Life Years; USA: United States of America; WT: wait times.

**Table 1:** Legend: First Author by last name and year of publication; if a study comprises more than one publication of all papers, first author and year publication is reported. Setting is where the study took place. Number of PAs was extracted from the publication or communication with an author. Design was whether it was randomly controlled, prospective, or retrospective. Question was the research question or hypothesis. Intervention describes the role of the PA. Control describes the part of physician services without a PA.

## Risk of bias in individual studies

Thirty-five of 39 studies in this review had a low risk of bias when assessed by the selection process, including missing data and results (See Appendix for details). However, three studies (20)(29)(43) scored a serious risk of bias, and one study (17) scored a critical risk of bias in terms of confounding variables. The risk of bias scores is summarized and displayed in Figure 2.

**Figure 2.** Risk of Bias: Cost-effectiveness Studies




### Outcomes of care

Outcomes of care studies were assessed for:

- Patient outcomes
- Process of care
- Accessibility of care
- Costs of care

The results are discussed below and displayed in Table 2.

**Patient outcomes**

Regarding Patient Outcome Evaluations, data in 30 studies were assessed. In 13 studies, the care provided by a PA was the same as the physician's usual care (16)(18)(20)(25)(26)(31-32)(36)(41)(47)(52-54). In 16 studies, the quality improved when the PA replaced a physician or was added as a member of a medical or surgical team (17)(21-23)(27)(28)(33)(34)(37)(38)(43)(46)(49)(51)(52)(54). Two studies showed a mixed outcome; one improved outcome and one remained the same (46)(50). Types of PA improvement varied from a reduction in complications of care (21-23)(28)(50), lower mortality (42), less hospitalization and readmissions (33)(38)(43)(51), fewer visits (37), and one demonstrated improvement in patient quality of life (27). Patient satisfaction of PAs did not significantly differ from the patient satisfaction of a physician in the three studies that reported this outcome. However, patients did not always distinguish that the PA was not a physician (16)(25)(51).

**Process of care**

In five studies, the process of care remained the same (19)(25)(27) (31)(35), and in four studies, the outcome improved with the addition of a PA (28)(30)(32)(34). Improvements were the use of thrombosis prophylaxis, beta-blockers, statins, or monitoring of blood pressure and blood glucose.

**Provider outcomes**

No studies reported the broader aspects of provider outcomes, such as workload or job satisfaction.

**Accessibility of care**

Four emergency department or acute care studies measured patient accessibility (15)(16)(28)(30). Three studies reported a decreased waiting time (15)(16)(28), and two studies showed a reduction in the proportion of patients leaving without being seen (15)(30).

**Costs of care**

Twenty-nine studies measured cost of care (14)(15)(18)(19)(20)(22-30)(32)(34)(35)(38)(39)(42)(46-54). In 18 studies, the cost-effectiveness had been operationalized by the length of a hospital or inpatient stay (LoS), length of visit (LoV) or length of procedure time. In three studies the PAs led to an increase in LoS (29)(34)(53) and in three studies no difference was found in either LoV or LoS (26)(44)(50). In 17 studies, the use of the PA

led to a reduction in the overall cost of care (15)(19)(20)(22-24)(28-30) (32) (34)(35)(39)(42)(46)(52)(54).

The cost of care, in monetary terms, measured in 11 studies, decreased with the introduction of a PA, or the results were equal to that of a physician alone (whether as a physician replacement or to improve the process of care (14)(24-27)(29)(35)(38)(39)(51)(53).

In one study, the cost of care by the PA was slightly greater than the physician's care (53). In another case, the PA provided a financial benefit when the reimbursement was at least 80% of an MD's charge (47).

Two studies (20)(22) researched the procedural times in cardiac angioplasty between cardiology fellows and a cardiology PA. The PA produced slightly faster procedure times with less fluoroscopic exposure time.

**Table 2.** Outcomes of care are based on the quality of care, accessibility of care, and cost of care.

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Althausen** 2013 (28) | Intervention vs control group:<br>• No differences in types of surgical complications; use of a PA decreased postoperative complication rates by 4.67% (p=0.0034) | Intervention vs control group:<br>• Use of deep vein thrombosis prophylaxis increased 6.73% (p=0.0084)<br>• Postoperative antibiotic administration increased by 2.88% (p=0.0302) | Intervention vs control group:<br>• Emergency department patients with orthopedic injuries were seen 205 minutes faster (p=0.006). Time to surgery improved 360 minutes (p=>0.03). | Intervention vs control group:<br>• Setup time was only marginally improved by 43 minutes, whereas operative time, time out of OR, and operative complication rates remained unchanged.<br>• The PA produced time savings for orthopedic surgeons.<br>• LoS (days) 7.96 (9.16) vs 8.57 (13.62) p=0.26620.<br>• Emergency department LoS: decreased per patient by 175 minutes (p=0.0001). |
| **Arnopolin** 2000 (29) | NA | NA | NA | Intervention vs control group:<br>• LoV with PA was 8 minutes longer (p=<0.001).<br>• LoV was 82 min and total charge $159, which was $8 less than MD charge (p=0.013) |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Capstack** 2016 (26) | No statistically significant differences were found in-hospital mortality and readmissions. | NA | NA | Intervention vs. control group:<br>• Patient charges was less ($2644 vs $2724); 95% CI 2.66%–4.39%, P<0.001.<br>• LoS and consultant use were not significantly different with PA. |
| **Costa** 2013 (17) | Intervention vs control group:<br>• PA procured lung injury rate was (1 of 197 [0.5%] vs 22 of 90 [24%], respectively).<br>• Rates for pulmonary graft dysfunction grade 2 and 3 (combined rates of 32.2% [29 of 90] vs 9.6% [19 of 197] in the control group) (p<0.01) | NA | NA | NA |
| **Decloe** 2015 (42) | Intervention vs control group:<br>• The proportion of deaths: 0.22 vs 0.26.<br>• In the pre- to post-intervention period; the proportion of deaths was 0.051 vs 0.055.<br>• Not statistically significant (p=0.14) | NA | NA | Intervention vs. control group:<br>• Average time to consult was 14.3 vs 21.4 h (p<0.0001).<br>• Improved LoS 16.2 days vs 20.5 days. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **De la Roche** 2021 (30) | NA | NA | In the PA group, there was a lower average daily 'left without being seen' rate (3.4% vs 5.2%; p<.001). | The average LoV was 348.91 minutes for the control group and 313.85 minutes for the intervention group (p<.001). |
| **DeMots** 1987 (20) | Intervention vs control group:<br>• The outcomes (complication rates and mortality) were the same. | NA | NA | Intervention .vs control group:<br>The cardiac catheterization procedure time for the PA and fellows was 41minutes ± 13 minutes and 44minutes ± 18 minutes. |
| **Dhuper** 2009 (43) | Intervention vs control group:<br>• All-cause and case mix index-adjusted mortality was 1.94% vs 2.85% (p≤.001).<br>• The adverse event cases were 5 vs 9 (p=.29).<br>• Readmission rate within 30 days was 64 vs 69 (p=.34).<br>• Patient satisfaction was 95% vs 96% (p=0.33). | NA | NA | NA |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Drennan** 2014 (25) & **de Lusignan** 2016 (44) | Intervention vs control group:<br>• Patient satisfaction was the same between the intervention and control groups.<br>• Most of the patients in the intervention group responded that they would be willing to consult a PA again (87.3%, 192/220), while 4.1% (9/220) preferred to consult a GP. | Intervention vs control group:<br>• No differences in the rates of prescriptions issued (1.16, 95% CI=0.87 to 1.53, p=0.31).<br>• Patient records of initial consultations of patients (n=99) in the intervention and control group (n=145) were judged as appropriate by GPs independent of the study (p<0.001).<br>• All consultations were assessed as safe, but GPs (control group) were rated higher in quality.<br>• More patients with chronic problems were seen in the control group and significantly more patients presenting for 'minor problems or symptoms' were seen in the intervention (PA) group. | NA | There were no significant differences in:<br>• Rates of re-consultation (rate ratio 1.24, 95% confidence interval [CI] =0.86 to 1.79, p=0.25).<br>• Rates of diagnostic tests ordered (1.08, 95% CI=0.89 to 1.30, p=0.44), referrals (0.95, 95% CI=0.63 to 1.43, p=0.80).<br>• The adjusted average consultation time in the PA group was 5.8 minutes longer than in the physician (control) group (95% CI=2.46 to 7.1; p<0.001).<br>• The cost per consultation in the PA group was lower (£6.22) (95% CI = –7.61 to –2.46, p<0.001). |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Everett** 2016 (45) | No clinically meaningful differences were observed between the intervention and control group in intermediate diabetes outcomes – also no differences with the PA as a solitary primary care provider. | NA | NA | NA |
| **Faza** 2018 (35) | NA | A chronic disease cohort of 185,694 patients was assigned to the control group and 66,217 assigned to the intervention group. Measurements included blood pressure, beta-blockers, statins, antiplatelets, primary or specialty care visits, lipid panels, and the number of stress tests ordered was comparable between groups. | NA | Intervention vs control group:<br>• No differences in using resources between the two groups. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Fejleh** 2020 (19) | NA | PAs performed flexible sigmoidoscopies comparably to gastroenterologists. The technical performance and quality metrics of the PA demonstrated higher cecal intubation rates than gastroenterologists. Comparisons of attending physicians and PAs grouped by years of experience did not show differences in performance. | NA | PAs performed superior to GI fellows with regard to intubation time (7.8 min versus 13.2 min, $p<0.001$) and were found to have a shorter withdrawal time (9.6 min versus 11.5 min). No significant difference was found between the intubation time of PAs and attending gastroenterologists (7.8 min versus 8.8 min, respectively, $p=0.25$). |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Fung** 2020 (34) | Intervention vs control group: The 30-day mortality was lower in the intervention group. (Intervention group: 26.85; control group 42.03, p<0.07) | Intervention vs control group:<br>• There was a difference in the quality of the admission note; the intervention group scored better: (score <0.5 28.65%; vs control group <0.5 56.15%, p<0.003). This quality reflected both admission notes being present, score=1, and a further 1.0 if it included a family history (0.5) and listed meds/allergies (0.5).<br>• Also, the quality medication transfer list score was better by the intervention group (scored on quality on the medication transfer list: intervention 80.19%; control 99.2%, p<0.08). | NA | Intervention vs control group:<br>• hospital LoS (intervention group median 7 days; control group 5 days, p<0.002)<br>• ICU length of stay (intervention group 69 hours; control group 48 hours, p<0.002).<br>• No significant differences in hospital readmission (intervention 35.06; control 42.29, p=0.46) |
| **Glotz-becker** 2013 (46) | • Mortality between the two groups was not significantly different.<br>• The mean number of consults was less in the intervention group: 1.47 vs 2.11 (P 0.03) for the control group. | Intensive care unit transfers between the two groups were not significantly different. | NA | Intervention group:<br>• LoS 30.9 days (P 0.03); 14-day readmission rate zero (P 0.03).<br>• Control group:<br>• LoS 36.8 days (p=0.03).<br>• The 14-day readmission rate was 10.6% (p=0.03). |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Goldman** 2004 (21) | Intervention vs. control group:<br>• Total complication rates were 22.0 per 1000 procedures (95% confidence interval [CI]=11.9, 39.2) vs 23.3 per 1000 procedures (95% CI=14.5, 36.8) (p=0.88). | NA | NA | NA |
| **Grzybicki** 2002 (47) | NA | NA | NA | • PA had a same-task substitution ratio (0.86) as MD and compensation to production ratio of 0.36.<br>• Compared with an MD, the annual revenue generated $99,360 (0.56 FTE). Weekly visit rates were the same. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Halter** 2020 (31) | Emergency medicine re-admittance rates within 7 days (n=194 & 6.1%) showed no difference between PAs & MDs (OR 0.87, 95% CI 0.61 to 1.24, p=0.437). | Almost all patient records were clinically adequate. PAs were evaluated as assessing patients in a similar way to second-year doctors-in-training.<br>If seen by a PA, patients were more likely to receive an X-ray investigation (OR 2.10, 95% CI 1.72 to 4.24, p<0.001) after adjustment for patient characteristics, triage severity of the condition, and statistically significant clinician intraclass correlation. | NA | NA |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Hooker** 2002 (48) | NA | NA | NA | In total, 262,490 medical office visits were analyzed for acute conditions as longitudinal episodes of care seen solely by a PA or MD. Patient age, health status, and gender were matched. The use of resources was the same for the PA, the MD, and the outcomes were the same. The labor cost of a PA was 40% that of the MD. PAs cost-effectiveness assessed the resources used for a care episode compared to the MD was slightly less. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Hooker** 2004 (49) | Duration of patient's disability (return to work) was shorter by 1.8 days for PA than MD. | OEM PAs assessed patients the same way as OEM MDs. | NA | In total, 80,764 encounters were analyzed for an acute episode of care seen solely by a PA or MD. The injury severity scale, patient age, and gender were matched for both providers. The use of resources was the same, but the number of days for disability was shorter for the PA. PA cost of care is 50% less due to wages. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Jackson** 2018 (36) | No clinically significant variation was found among the intervention and control group concerning diabetes outcomes, suggesting that similar chronic illness outcomes may be achieved by physicians, PAs, and NPs equally. The difference in A1c values compared with physicians was -0.05% (95% CI, -0.07% to 0.02%) for NPs and 0.01% (CI, -0.02% to 0.04%) for PAs. For systolic BP, the difference was -0.08 mm Hg (CI, -0.34 to 0.18 mm Hg) for NPs and 0.02 mm Hg (CI, -0.42 to 0.38 mm Hg) for PAs. For LDL-C, the difference was 0.01 mmol/L (CI, 0.00 to 0.03 mmol/L) (0.57 mg/dL [CI, 0.03 to 1.11 mg/dL]) for NPs and 0.03 mmol/L (CI, 0.01 to 0.05 mmol/L) (1.08 mg/dL [CI, 0.25 to 1.91 mg/dL]) for PAs. | NA | NA | NA |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Kawar** 2011 (50) | Intervention group vs control group:<br>• Renal insufficiency 22% vs 25% (P–0.05).<br>• Cerebrovascular accidents 5.6% vs 4% (p=.02).<br>• No in-hospital difference of mortality or intensive care unit mortality between the two groups. Survival analyses showed no difference in 28-day survival between the two groups. | NA | NA | A PA-run MICU produced no significant differences in survivorship compared to a resident-run MICU: Hospital average LoS was similar between the intervention and control group. Medical Intensive Care Unit LoS: There was no difference between the intervention and control group after correcting for confounders. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Krasuski** 2003 (22) | Intervention group vs control group: Complication ratio 0.54%; vs 0.58%. | NA | NA | Intervention group vs control group: procedural times 70.2 minutes (± 32.6 minutes), vs 72.6 (± 35.2 min); p=0.045) use of fluoroscopic imaging 10.2 minutes (± 6.5 minutes) vs 12,2 minutes (±9.9 min); P 0.001. No difference in the volume of contrast media was seen between the two groups. |
| **Kuo** 2013 (51) | Nursing home residents (patients) with Principal Care Providers (PCPs: MDs, PAs, or NPs) who devoted less than 5% of their clinical effort to nursing home care were at 52% higher risk of potentially avoidable hospitalization than those whose PCPs committed 85% or more of their clinical effort to NHs. Hazard ratio=1.52, 95% confidence interval=1.25–1.83. | NA | NA | The annual Medicare spending (cost) was $2,179 higher than the intervention (PA) group in the control group. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Malloy** 2021 (24) | NA | NA | NA | Intervention vs. control group: procedures in the control group took 34 minutes longer and were $3,750 more expensive (p<0.01, both). |
| **Morgan** 2008 (37) | Patients in the intervention (PA) group had 16% fewer office-based visits per year than those receiving care in the control (MD) group (p=<0,01). | Patients in the PA group had about 25 percent fewer emergency department visits ( p<0.05). The results for hospital outpatient and inpatient settings were not statistically significant. | NA | NA |
| **Morgan** 2019 (38) | Patients of PAs were less likely than MDs to incur hospitalization related to their ambulatory care (PA vs MD OR: 0.92, 95% CI: 0.8446, 0.997). | NA | NA | PAs incurred fewer resources than MDs for the same matched group of chronically ill patients even in expanded roles. Estimated annual medical expenditures of PAs vs MDs: total (inpatient, outpatient, pharmacy) $32,350 vs $34,650. The estimated mean ratio for differences in expenditures is 0.93 (p<0.01). |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Nestler** 2012 (15) | NA | NA | • Emergency waiting room times (LoV) were similar between the intervention group and the control group.<br>• Intervention group vs control group: Proportion of patients leaving without being seen was 1.4% vs 9.7% (p<0.001). | Intervention group vs. control group:<br>• Length of visit: 229 vs 270 minutes [95% CI 168 to 303] (p<0.001)<br>• Treatment room times=151 [92 to 223] minutes vs 187 minutes (p<0.001). |
| **Ngcobo** 2018 (23) | Intervention group vs control group:<br>• Adverse events occurred during circumcisions 7.1% (n=4195) vs 8,1% (n=543) (p=0.385).<br>• Recorded pain, bleeding, swelling, infection, and no wound destruction differed between the intervention and control groups. | NA | NA | Intervention group v.s control group:<br>• Procedure time 14.63 minutes vs 15.25 (p= <0.001). |
| **Oswanski** 2004 (32) | No differences between intervention and control mortality rates. | Focused analysis showed 100 percent participation in the intervention group (PAs) during the trauma alert compared to 51 percent by MD residents. | NA | Intervention group vs. control group:<br>• LoS was 2.54±4.65 vs 3.4±5.81 (p= <0,05)<br>• LoS (from entry to the ward floor) was statistically reduced by 1 day in the intervention group. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Pavlik** 2017 (33) | Intervention group (PA) vs control group – emergency physician (EP):<br>• Return rate 6.8% vs 8.0% . For the PA & EP group, the return- rate was 9.3%.<br>• Recidivism (return) rates for the 3 clinical groups were: PA (6.8%), EP (8.0%), and PA & EP (9.3%) (p<0.03).<br>• Patients admitted to the hospital on their return visits for the 3 clinical groups were as follows: PA (0.4%), EP (0.6%), and jointly PA-EP (0.7%) (p=0.2). | NA | NA | NA |
| **Resnick** 2016 (18) | No significant differences were found in postoperative complications. | NA | NA | Intervention group vs control group:<br>• Average total procedure cost decreased by $75.08 (p<.001).<br>• The time that the oral and maxillofacial surgeon was directly involved in the procedure decreased on average 19.2 minutes (p<.001). |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Roy** 2008 (52) | There is no difference in inpatient mortality, readmissions, or patient satisfaction. | There is no difference in the ICU transfers. | NA | • There is no difference in the LoS.<br>• The total cost of care was marginally lower on the intervention group (adjusted costs 3.9% lower; 95% confidence interval [CI] 27.5% to 20.3%) |
| **Singh** 2011 (53) | The risk of readmission at 7, 14, and 30 days and the risk of inpatient death were similar between the intervention and control groups. | NA | NA | Intervention group vs. control group:<br>• Hospitalizations were associatedwith a 6.73% longer LoS (p=0.005) in the intervention group; 3.17 days vs 2.99 days. Costs (charges) difference of 6.45% p=0.07 $9,390 vs $9,044. |
| **Smith** 2020 (39) | NA | NA | NA | Patients of PAs have lower odds of inpatient admission [odds ratio for PA vs. MD 0.92, 95% CI=0.87–0.97], and lower emergency department use (0.67 visits on average for PAs, 95% CI=0.56–0.63). This translates into PAs having ~$500–$700 less healthcare costs per patient per year (p<0.0001) than MDs |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Theunissen** 2014 (16) | No differences in mortality and complaints between the intervention and control group. | NA | Intervention vs. control:<br>• Overall waiting time (median: -41 min) p<0.0001.<br>• The median overall LoS was also significantly shorter (-12 min) p<0,0001 | NA |
| **Timmermans** 2017 (27) & **Bos** 2018; (55) & **Timmermans** 2017 (56) | Intervention vs control group:<br>• QALY gain: +0.02 (95% CI −0.01 to 0.05).<br>• Improved patient experiences (ß 0.49, 95% CI 0.22-0.76, p=.001) | There are no significant differences between the intervention and control groups concerning the adherence to guidelines on medication prescribing or other indicators for quality and safety of care. | | Intervention group vs. control group:<br>• Personnel costs per patient for the provider primarily responsible for medical care on the ward were lower on the wards (−€11, 95% CI −€16 to −€6, p<0.01).<br>• A cost difference of €309 per patient (95% CI €29 to €588, p=0.030) was found in favor of the control group regarding the LoS.<br>• Total costs per patient did not significantly differ between the groups (+€568, 95% CI −€254 to €1391, p=0.175). |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Tompkins** 1977 (14) | NA | NA | NA | • Intervention vs. control: Diagnostic test costs by the PA were less than the MD control group ($4.26 vs $5.48). (p<0.05).<br>• Direct medical care costs were significantly lower: intervention=$12.78 vs control=$16.86. |
| **van Rhee** 2002 (54) | No difference with inpatient mortality, readmissions, or patient satisfaction. | No difference in ICU transfers. | NA | The total cost of care was marginally lower on the intervention group (adjusted costs 3.9% lower; 95% confidence interval [CI] −7.5% to −0.3%), but LoS was not significantly different (adjusted LOS 5.0% higher; 95% CI, −0.4% to +10%) as compared with the control group. |

| First author & Year of Publication (reference #) | Quality of Care | | Accessibility of Care | Costs of Care |
|---|---|---|---|---|
| | Patient Outcomes | Process of Care Outcomes | | |
| **Yang** 2018 (40) | Median hemoglobin A1c was comparable at diagnosis (6.6%, 6.7%, 6.7%, p>0.05) and after 4 years (all 6.5%, p>0.05). A1c levels at initiation of the first (7.5%-7.6%) and second (8.0%-8.2%) oral medications for patients of PA and NPs compared with that of physicians was also similar after adjusting for patient characteristics (all p>0.05). | NA | NA | NA |

For the most part, the reviewed studies in Table 2 did not produce a significant 'differences of effect' analysis. We note that in two ambulatory studies, the employment of the PA was associated with a slightly longer patient LoV (by a few hours). However, the cost of patient care when delivered by a physician exceeded the cost of care provided by PA (25)(29).

Three studies examined care outcomes by assessing cost-benefit and cost-utility – measuring the downstream cost-effectiveness of care or services (25)(38)(48). In the Hooker 2002 study (48) and the Morgan 2019 study (38), the PAs did not negate their cost-benefit of less expensive labour by ordering more resources for an episode of care. In addition to the reduced labour cost, the medical resources used for an episode of care were less in the aggregate for the PA than the matched physician's resources for the same episode of care.

In five studies, the PA was employed not as a direct replacement for a physician but in response to increased demand for care (14-18). Still, when added to the medical staff, the PA significantly improved the throughput of patient services (e.g., maxillofacial surgery, emergency department, or lung procurement for transplantation). In each instance, the inclusion of a PA resulted in time per patient saved. When a PA was introduced in a newly created fast track system in the emergency department, the 'through put' of patients improved, and patient waiting time decreased (16). In these studies, no calculation was made of cost-effectiveness in terms of hospital, training, or healthcare costs at a national level. Nor were there any studies that researched the provider's workload or job satisfaction.

## Discussion

This review of 39 studies involved synthesizing the evidence on the cost-effectiveness of PA employment. Thirty-two studies presented a retrospective data analysis. The majority of the research focused on a physician substitution effect (34 out of 39 studies). Five studies focused on the impact of PA employment along with their contribution to the efficient production of medical services (14-18). While the retrospective studies were methodological sound, such ex post facto design is of lower grade than prospective ones. At the same time, higher levels of evidence, such as randomized controlled trials, are not often applicable as it is challenging to randomize healthcare workers since patients cannot be blinded to healthcare professionals.

Throughout the assessed reports, the question raised most often was whether the PA provided adequate care, cost-efficient care, or improved

quality of care. In the aggregate, the costs of care were improved in 24 studies. In 16 cases, the quality of care was the same as that provided by a physician, and only in two studies did the visit time attributed to the PA lengthen (27) (53). In one study, the consult time of the PA slightly increased compared to the physician's consult time (25).

Rarely did these studies examine the broader organizational effect of whether the addition of a provider improves overall organizational efficiency. Drennan et al. point out that when the PA's service was incorporated in the cost-effectiveness analysis, this addition could have a broader impact on the cost of health services through referrals and prescriptions (25). However, the authors concluded no significant differences in physician and PA rates of prescribing, ordering, referring, and consultation was found. As such, the costs were not assigned.

In terms of procedures, the outcome of circumcisions performed by a PA did not differ statistically from those of physicians. In contrast, the effects of performing surgical abortions, angioplasties, colonoscopies, and explanting lungs by PAs produced better outcomes compared with the physician's performance.

As a result of this systematic review, it is apparent that PAs are cost-effective in their delivery of patient care. Furthermore, their role as team members improved the quality of care through the input, throughput, or output. Although the labor cost of a PA versus a physician was implied in 15 studies, it was only categorically addressed in the Grzybicki (47), Hooker (49), and Timmermans study (27). Aside from these examples, the implication is that physician employment cost and educational costs are higher than a PA.

The findings that emerge from this consolidated analysis are generalizable. They transcend five countries and represent the broad span of PA employment: acute care settings, medical and surgical wards, proceduralists, and facilitators of patient throughput. As a timeline, the published dates of the studies represent almost half a century of critical observation of PAs (1977–2021). The included studies offer a timeframe of cost-effectiveness of emerging roles of PAs and how their use expanded from their early introduction in small practices to contemporary medical centers in the 21st century.

The first economic studies using a time-motion method to observe the interaction of PAs and physicians regarding patient care were in the USA and published at a time when the development of the profession was still in its infancy (6)(14). Early studies included some details of the PA, then known as a "new health professional," and drew on the limited literature known at the time (57).

In studies before the 1980s, the PA often worked in a protocol-driven context (58). In observations after the 1980s, the PA profession was more established in healthcare and similar to today's professional profile, where the PA executes tasks independently. Their contemporary activity is viewed as an integrated member of a medical team (59).

From the 1990s onwards, the PA became more of a substitute for physician services in the role of a modern team player with a set of responsibilities (22)(29)(32)(38)(43)(47)(54). By the new century, more countries had adopted the PA concept and drew on the American experience to develop their own professional PA profile (16)(23)(25)(31)(42).

Another observation of adding a PA was based on the decades of experience in the US and Canada for new PA adopters in Africa, Australia, and Europe. As the PA was considered in Europe in the new century, the implementers could draw on the experience, literature, demonstration studies, government reports, and observations of PAs at work to know how to best use their services and define their role (25). By the second decade, the economics of their effectiveness had become more rigorous, as seen in the study of Timmerman and colleagues on cost-utility and Morgan's and colleague's studies of the cost-effectiveness of chronic disease management (38)(56). In essence, each team of researchers was able to sophistically account for the downstream effect of PA utility on 17 inpatient wards across the Netherlands and 170 VA medical centers with their associated 1,400 outpatient clinics.

When the various research questions posed in the included studies are analyzed, the PA's Scope of Practice (SoP) differed. Sometimes the PA's SoP was narrow; for example, independently performed surgical procedures as in circumcisions, lungs harvesting, surgical abortions, and cardiac catheterization. In other situations, they had broad medical tasks backfilling the physician's role on a ward or as an additional provider in an acute care setting with a commensurate SoP. In none of the articles did the researchers relate the SoP to the fourth goal in the "quadruple aim" of healthcare (i.e., taking care of health professionals) (60). That raises the question of whether the performance of any procedure contributes to the experience of joy in their work as healthcare professionals (61). However, the analysis of a half-century of PA job satisfaction literature suggests that almost all PAs find their role satisfying (62).

For the most part, the studies took place after the PA had been introduced into the organizational setting. In these situations, the outcomes before and after were compared. In five studies, the PA was added to a team (e.g., as part of a hospitalist service) or as a need to expand the medical staff (14-18). Along with introducing a PA, organizational changes

reflected on how services would be enhanced or improved. An example of organizational change is illustrated by Decloe et al. (42). The PA was added to the infectious disease consulting service to mitigate the length of stay and patient morbidity and mortality in a Canadian hospital (42). In another study, the medical residents that served as hospitalists were replaced with PA hospitalists in a small community hospital (43). Both settings required significant organizational changes in staffing, hospital bylaws, on-boarding, and oversight of the PA.

We note that in the majority of studies in this review, the profiles of the PAs were missing. Most findings came up short on information as to the experience the PA brought to the setting. The exception was the de Lusignan study that noted the provider's gender and experience (44).

Supervision of the PA by the physician was considered a necessary activity, especially during the first decade or so of the introduction of the PA profession. When a supervising physician took time off from their patient schedule to supervise the PA's care or medical notes, the time was deducted from the PA's employment benefits (6). In 11 studies, this variable was noted, but only one study calculated the economic effect (27). Many studies indicated that when comparing medical or surgical residents and PAs, the supervision by an attending physician or senior consultant was equal. Two studies identified that the use of the PA saved time for the medical specialist without having operationalized it further (18)(28).

Finally, we note that the effects of introducing a PA in several studies can be seen from the perspective of complex organizational change. The evaluation of a PA's introduction, often as a new health professional in the chain of care, is not the same as a treatment intervention. One of the first scholars of PA effectiveness noted: "As a theory, productivity is a simple concept: it measures changes in the total output that occurs when small changes are made in one factor of production, with all other factors and circumstances held constant. Because these conditions can be met in the real world only rarely, productivity numbers are almost always rough estimates. Certainly, that is the case concerning PAs." (6).

## Limitations

One limitation of this analysis is that the settings and the outcome parameters differed across studies, and the characteristics of the PA were often missing. More granular PA and physician information is needed to understand what could be influencing or confounding variables that affect the actual outcome. Variables missing across almost all studies are

the experience, educational level, number of involved PAs, and their age, gender, and background.

Another limitation was the need to separate the outcomes of the employment of the PA and NP. We omitted studies where the combined labor was not isolated. In five cases, we inquired whether the two providers could be separated for analysis. Understanding where the division of labor exists when three medical professionals work together is a health services research area that needs further exploration.

One strength of this systematic review was the reliance on peer-reviewed and published studies. As a result, various government-initiated PA demonstration projects promulgated as reports were excluded as not peer-reviewed (referred to as 'grey literature'). Another strength was the breadth of the search that provided clear insight into the PA profession's different effects and development. With the help of an experienced librarian, the research question was carefully operationalized. Combined with a reference check at the end of the process, the risk of missing relevant articles was significantly reduced.

## Conclusion

The PA of the 21st century is a semi-autonomous health professional who is a part of contemporary medical treatment teams. When peer-reviewed published studies spanning three continents were examined for quality of care, accessibility, and cost-effectiveness of employment, the PA was comparable to the physician in producing similar results in almost every case. Although some of the studies suggest that the addition of a PA resulted in a similar quality of care as physicians, in a few instances, their utilization enhanced the overall quality of care. In most instances, the introduction of a PA leads to the same or an improved quality of care, and their employment is cost-efficient when considering the labor and educational costs. These economic findings were observed in prospective and retrospective designs and various settings, whether primary care in outpatient offices or secondary (hospital-based) care. The results of the collective studies have produced a sizeable contextual understanding of efficient outcomes of care when the PA is a part of the medical team.

**Abbreviations**

| | | |
|---|---|---|
| AF | = | Air Force |
| CA | = | Canada |
| CINAHL | = | Cumulative Index to Nursing and Allied Health Literature |
| ED | = | Emergency Department (includes A & E) |
| ICU | = | Intensive care units |
| IR | = | Ireland, Republic of |
| MD | = | physician/medical doctor. Includes American DOs |
| NL | = | Netherlands |
| NP | = | Nurse Practitioner |
| NS | = | Not stated in the manuscript |
| OEM | = | Occupational and Environmental Medicine |
| PA | = | Physician Assistant or Physician Associate |
| QALY | = | Quality Adjusted Life Year |
| ROBINS-I | = | Risk of Bias in Non-randomized Studies of Interventions |
| SA | = | South Africa |
| SoP | = | Scope of Practice |
| UK | = | United Kingdom |
| USA | = | United States of America |
| VA | = | Department of Veterans Affairs |
| VHA | = | Veterans Health Administration |
| WOS | = | Web of Science |

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## Appendix 1. ROBIN-I assessment

| Author | Domain 1: confounding | Domain 2: selection | Domain 3: classification of intervention | Domain 4: deviation from interventions | Domain 5: missing data | Domain 6: measurement of outcomes | Domain 7: selection of reported result | ROBINS-I overall |
|---|---|---|---|---|---|---|---|---|
| Althausen 2013 | 3 | 1 | 1 | 3 | 1 | 1 | 1 | 2 |
| Arnopolin 2001 | 3 | 2 | 3 | ni | ni | 1 | 1 | 3 |
| Capstack 2016 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | 2 |
| Costa 2013 | 4 | 1 | 3 | ni | ni | ni | 1 | 4 |
| Decloe 2015 | 4 | 4 | 1 | 1 | ni | 1 | 1 | 2 |
| Dhuper 2009 | 4 | 2 | 1 | 2 | ni | 2 | 1 | 3 |
| Drennan 2015 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 |
| Everett 2019 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fung 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Glotzbecker 2012 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| Goldman 2004 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| Grzybicki 2002 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Hooker 2002 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Hooker 2004 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Kawar 2011 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Krasuki 2003 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Kuo 2013 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Morgan 2008 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 |
| Nestler 2012 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Ngcobo 2017 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Oswanski 2004 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Pavlik 2017 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Resnick 2016 | 3 | 1 | 1 | 1 | 3 | 1 | 1 | 2 |
| Singh 2011 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |

| Author | Domain 1: confounding | Domain 2: selection | Domain 3: classification of intervention | Domain 4: deviation from interventions | Domain 5: missing data | Domain 6: measurement of outcomes | Domain 7: selection of reported result | ROBINS-I overall |
|---|---|---|---|---|---|---|---|---|
| Theunissen 2014 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Timmermans 2017 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| Tompkins 1977 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| Van Rhee 2002 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 |
| Yang 2018 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Jackson 2018 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Faza 2018 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Roy 2008 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| de la Roche 2021 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 2 |
| Malloy 2020 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| DeMots 1987 | 3 | 1 | 1 | 1 | 3 | 3 | 1 | 3 |
| Morgan 2019 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fejleh 2020 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 |
| Halter 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Smith 2020 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | 22 | 36 | 33 | 32 | 29 | 34 | 38 | 26 |
| 2 | 9 | 2 | 3 | 2 | 2 | 1 | 1 | 9 |
| 3 | 5 | 0 | 3 | 0 | 4 | 3 | 0 | 3 |
| 4 | 3 | 1 | 0 | 3 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 0 | 2 | 4 | 1 | 0 | 0 |
| | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 |

## Appendix 2. Search strategy

**Cinahl**

**S1** MH "Physician Assistants" OR (TI ((physician N1 (assistant* OR associate* OR extender* OR substitute*)) OR (medical W1 extender*) OR (advanced W1 provider*) OR (emergency W1 practitioner*) OR ((Midlevel OR (mid W1 level) OR ((non OR none) W1 physician*) OR nonphysician*) W2 (clinic* OR ((health OR healthcare) W2 (professional* OR provider* OR worker*)) OR personnel OR practitioner* OR professional* OR provider* OR staff OR worker* OR specialist* OR (first W1 assistant*))) OR (midlevel W1 health W1 care) OR (advance* W1 practice W1 provider*))) OR (AB ((physician N1 (assistant* OR associate* OR extender* OR substitute*)) OR (medical W1 extender*) OR (advanced W1 provider*) OR (emergency W1 practitioner*) OR ((Midlevel OR (mid W1 level) OR ((non OR none) W1 physician*) OR nonphysician*) W2 (clinic* OR ((health OR healthcare) W2 (professional* OR provider* OR worker*)) OR personnel OR practitioner* OR professional* OR provider* OR staff OR worker* OR specialist* OR (first W1 assistant*))) OR (midlevel W1 health W1 care) OR (advance* W1 practice W1 provider*))) OR (SU ((physician N1 (assistant* OR associate* OR extender* OR substitute*)) OR (medical W1 extender*) OR (advanced W1 provider*) OR (emergency W1 practitioner*) OR ((Midlevel OR (mid W1 level) OR ((non OR none) W1 physician*) OR nonphysician*) W2 (clinic* OR ((health OR healthcare) W2 (professional* OR provider* OR worker*)) OR personnel OR practitioner* OR professional* OR provider* OR staff OR worker* OR specialist* OR (first W1 assistant*))) OR (midlevel W1 health W1 care) OR (advance* W1 practice W1 provider*)))

**S2** (MH "Costs and Cost Analysis+" OR MH "Economic Aspects of Illness" OR MH "Insurance+" OR MH "Referral and Consultation+") OR (TI (((Spend* OR Fund* OR Expen* OR Budget) N1 (control* OR saving* OR care OR health* OR high OR medical)) OR champus OR (Claim* N1 (analysis OR review* OR Analysis)) OR Coinsurance* OR (Competitive N1 (Health* OR medical) N1 Plan*) OR Costeffect* OR Deductible* OR (direct W1 cost*) OR (Economic N1 evaluat*) OR (Health N1 Benefit N1 Plan*) OR insuran* OR (managed N1 car*) OR medicare OR (Preferred N1 provider*) OR Reimburs* OR (Third N1 Party N1 Pay*) OR (Usage N1 reduction*) OR (Value N1 Based N1 Purchas*) OR (Worker* N1 Compensation*) OR (Return N1 on N1 investment*) OR ROI OR ((Cost OR costs) N1 (allocat* OR analy* OR apportionment* OR benefit* OR compar* OR contain* OR control*

OR decreas* OR effective* OR Efficien* OR evaluat* OR increase* OR manag* OR minimi* OR reduc* OR saving* OR sharing OR shifting* OR minimization OR minimization OR (health N1 care) OR health* OR high* OR low* OR increas* OR medical OR rising OR societal OR Treatment)))) OR (AB (((Spend* OR Fund* OR Expen* OR Budget) N1 (control* OR saving* OR care OR health* OR high OR medical)) OR champus OR (Claim* N1 (analysis OR review* OR Analysis)) OR Coinsurance* OR (Competitive N1 (Health* OR medical) N1 Plan*) OR Costeffect* OR Deductible* OR (direct W1 cost*) OR (Economic N1 evaluat*) OR (Health N1 Benefit N1 Plan*) OR insuran* OR (managed N1 car*) OR medicare OR (Preferred N1 provider*) OR Reimburs* OR (Third N1 Party N1 Pay*) OR (Usage N1 reduction*) OR (Value N1 Based N1 Purchas*) OR (Worker* N1 Compensation*) OR (Return N1 on N1 investment*) OR ROI OR ((Cost OR costs) N1 (allocat* OR analy* OR apportionment* OR benefit* OR compar* OR contain* OR control* OR decreas* OR effective* OR Efficien* OR evaluat* OR increase* OR manag* OR minimi* OR reduc* OR saving* OR sharing OR shifting* OR minimization OR minimization OR (health N1 care) OR health* OR high* OR low* OR increas* OR medical OR rising OR societal OR Treatment)))) OR (SU (((Spend* OR Fund* OR Expen* OR Budget) N1 (control* OR saving* OR care OR health* OR high OR medical)) OR champus OR (Claim* N1 (analysis OR review* OR Analysis)) OR Coinsurance* OR (Competitive N1 (Health* OR medical) N1 Plan*) OR Costeffect* OR Deductible* OR (direct W1 cost*) OR (Economic N1 evaluat*) OR (Health N1 Benefit N1 Plan*) OR insuran* OR (managed N1 car*) OR medicare OR (Preferred N1 provider*) OR Reimburs* OR (Third N1 Party N1 Pay*) OR (Usage N1 reduction*) OR (Value N1 Based N1 Purchas*) OR (Worker* N1 Compensation*) OR (Return N1 on N1 investment*) OR ROI OR ((Cost OR costs) N1 (allocat* OR analy* OR apportionment* OR benefit* OR compar* OR contain* OR control* OR decreas* OR effective* OR Efficien* OR evaluat* OR increase* OR manag* OR minimi* OR reduc* OR saving* OR sharing OR shifting* OR minimization OR minimization OR (health N1 care) OR health* OR high* OR low* OR increas* OR medical OR rising OR societal OR Treatment))))

**S3** (MH "Waiting Lists") OR (TI (waitlist* OR delist* OR (wait*N1 (period OR list* OR time)))) OR (AB (waitlist* OR delist* OR (wait*N1 (period OR list* OR time)))) OR (SU (waitlist* OR delist* OR (wait*N1 (period OR list* OR time))))

**S4** (MH "Hospitalization") OR (MH "Diagnosis-Related Groups") OR (MH "Outliers, DRG") OR (MH "Transfer, Intrahospital") OR (MH "Length of Stay") OR (MH "Patient Admission") OR

(MH "Patient Discharge+") OR (MH "Patient Dumping") OR (MH "Readmission") OR (TI (Hospitaliz* OR Hospitalis* OR Admission* OR Discharg* OR Handoff* OR (Hand* W1 (Over* OR off)) OR (Sign W1 Out*) OR Signout* OR Handover* OR Readmis* OR ((healthcare OR care OR patient) N1 (transfer* OR transition*)) OR (Patient N1 (Turfing* OR Dumping*)) OR ((Duration OR Hospital OR Length*) N1 stay*))) OR (AB (Hospitaliz* OR Hospitalis* OR Admission* OR Discharg* OR Handoff* OR (Hand* W1 (Over* OR off)) OR (Sign W1 Out*) OR Signout* OR Handover* OR Readmis* OR ((healthcare OR care OR patient) N1 (transfer* OR transition*)) OR (Patient N1 (Turfing* OR Dumping*)) OR ((Duration OR Hospital OR Length*) N1 stay*))) OR (SU (Hospitaliz* OR Hospitalis* OR Admission* OR Discharg* OR Handoff* OR (Hand* W1 (Over* OR off)) OR (Sign W1 Out*) OR Signout* OR Handover* OR Readmis* OR ((healthcare OR care OR patient) N1 (transfer* OR transition*)) OR (Patient N1 (Turfing* OR Dumping*)) OR ((Duration OR Hospital OR Length*) N1 stay*)))

**S5** (MH "Mortality+") OR MW "MO" OR (TI (Mortalit* OR (Case N1 Fatality N1 Rate*) OR (Death N1 Rate*) OR (Fatal N1 Outcome*))) OR (AB (Mortalit* OR (Case N1 Fatality N1 Rate*) OR (Death N1 Rate*) OR (Fatal N1 Outcome*))) OR (SU (Mortalit* OR (Case N1 Fatality N1 Rate*) OR (Death N1 Rate*) OR (Fatal N1 Outcome*)))

**S6** (MH "Morbidity+") OR (TI (morbidit* OR comorbidit*)) OR (AB (morbidit* OR comorbidit*)) OR (SU (morbidit* OR comorbidit*))

**S7** (MH "Quality of Life+") OR (MH "Health Status+") OR (MH "Activities of Daily Living+") OR (MH "Quality-Adjusted Life Years") OR (TI ((Quality N1 Adjusted N1 Years) OR QALY OR (Healthy N1 Year* N1 Equivalent*) OR (Adjusted N1 Life N1 Year*) OR (life N1 qualit*) OR (quality N1 of N1 life) OR (health N1 status) OR (level N1 of N1 health) OR (health N1 level*) OR qol OR hrql OR hrqol OR (activities N1 of N1 daily N1 living) OR (daily N1 activit*) OR adl OR (chronic N1 limitation N1 of N1 activit*))) OR (AB ((Quality N1 Adjusted N1 Years) OR QALY OR (Healthy N1 Year* N1 Equivalent*) OR (Adjusted N1 Life N1 Year*) OR (life N1 qualit*) OR (quality N1 of N1 life) OR (health N1 status) OR (level N1 of N1 health) OR (health N1 level*) OR qol OR hrql OR hrqol OR (activities N1 of N1 daily N1 living) OR (daily N1 activit*) OR adl OR (chronic N1 limitation N1 of N1 activit*))) OR (SU ((Quality N1 Adjusted N1 Years) OR QALY OR (Healthy N1 Year* N1 Equivalent*) OR (Adjusted N1 Life N1 Year*) OR (life N1 qualit*) OR (quality N1 of N1 life) OR (health N1 status) OR (level N1 of N1 health) OR (health N1 level*) OR qol OR hrql OR hrqol OR (activities N1 of N1 daily N1

living) OR (daily N1 activit*) OR adl OR (chronic N1 limitation N1 of N1 activit*)))

**S8** (MH "Patient Satisfaction") OR (TI (Patient N1 (Satisfaction* OR preference* OR experienc*))) OR (AB (Patient N1 (Satisfaction* OR preference* OR experienc*))) OR (SU (Patient N1 (Satisfaction* OR preference* OR experienc*)))

**S9** (MH "Patient Compliance+") OR (TI ((medication OR Therapeutic OR Treatment OR Patient) N1 (Adher* OR Cooperat* OR ((Non OR none) N1 (Compli* OR adher*)) OR Nonadher* OR Noncompli*))) OR (AB ((medication OR Therapeutic OR Treatment OR Patient) N1 (Adher* OR Cooperat* OR ((Non OR none) N1 (Compli* OR adher*)) OR Nonadher* OR Noncompli*))) OR (SU ((medication OR Therapeutic OR Treatment OR Patient) N1 (Adher* OR Cooperat* OR ((Non OR none) N1 (Compli* OR adher*)) OR Nonadher* OR Noncompli*)))

**S10** (MH "Patient Safety") OR (MH "Adverse Health Care Event+") OR (MH "Health Care Errors+") OR (MH "Sentinel Event") OR (MH "Fire Safety") OR (MH "Electrical Safety") OR (MH "Chemical Safety") OR (MH "Radiation Safety") OR (TI (((Wrong N1 Procedure) OR Surgical OR Medical OR Diagnostic) N1 (Mistake* OR Error* OR (Wrong N1 Site N1 Surger*)) OR (Critical N1 Medical N1 Incident*) OR (Never N1 Event*) OR Misdiagnos* OR (False N1 (Negative OR positive) N1 Reaction*) OR ((Intraobserver OR Interobserver OR Observer*) N1 (Variation* OR bias OR Variabilit*)) OR (Near N1 Miss*) OR (Close N1 Call*) OR (Radiotherapy N1 Setup N1 Error*) OR ((Medication OR (Drug N1 Use)) N1 Error*) OR (patient N1 safet*))) OR (AB (((Wrong N1 Procedure) OR Surgical OR Medical OR Diagnostic) N1 (Mistake* OR Error* OR (Wrong N1 Site N1 Surger*)) OR (Critical N1 Medical N1 Incident*) OR (Never N1 Event*) OR Misdiagnos* OR (False N1 (Negative OR positive) N1 Reaction*) OR ((Intraobserver OR Interobserver OR Observer*) N1 (Variation* OR bias OR Variabilit*)) OR (Near N1 Miss*) OR (Close N1 Call*) OR (Radiotherapy N1 Setup N1 Error*) OR ((Medication OR (Drug N1 Use)) N1 Error*) OR (patient N1 safet*))) OR (SU (((Wrong N1 Procedure) OR Surgical OR Medical OR Diagnostic) N1 (Mistake* OR Error* OR (Wrong N1 Site N1 Surger*)) OR (Critical N1 Medical N1 Incident*) OR (Never N1 Event*) OR Misdiagnos* OR (False N1 (Negative OR positive) N1 Reaction*) OR ((Intraobserver OR Interobserver OR Observer*) N1 (Variation* OR bias OR Variabilit*)) OR (Near N1 Miss*) OR (Close N1 Call*) OR (Radiotherapy N1 Setup N1 Error*) OR ((Medication OR (Drug N1 Use)) N1 Error*) OR (patient N1 safet*)))

**S11** (MH "Quality of Health Care") OR (MH "Program Evaluation") OR (TI (((care OR healthcare OR (Health N1 Care)) N1 Qualit*) OR ((Institutional OR Protocol OR Policy OR Guideline) N1 (adherence OR Compliance)) OR "Outcome and Process Assessment" OR (Structure N1 Process N1 Outcome N1 Triad*) OR (Donabedian N1 (Model* OR Triad*)) OR (Outcome* N1 (Assessment* OR Research* OR Stud* OR Measure*)) OR (Failure* N1 to N1 Rescue*) OR (Patient N1 Outcome* N1 Assessment*) OR (Patient N1 Centered N1 Outcome* N1 Research) OR (((Patient N1 Relevant) OR Rehabilitation OR Treatment OR (Patient N1 Reported) OR (Critical N1 Care)) N1 Outcome*) OR ((Treatment OR Clinical) N1 (Effectiveness* OR Efficac*)) OR (Treatment N1 Failure*) OR (Process N1 (Assessment* OR Measure*)) OR (((Professional N1 Review) OR (Peer N1 Review) OR (Professional N1 Standards N1 Review)) N1 Organization*) OR PSRO OR "Utilization and Quality Control Peer Review Organizations" OR (Program N1 (Evaluation* OR Sustainabilit* OR Effectiveness OR Appropriateness)) OR (Best N1 Practice N1 Analysis) OR Benchmark* OR (((Health N1 Care N1 Quality) OR (Healthcare N1 Quality)) N1 (Assurance* OR Assessment*)) OR (Alert N1 Fatigue N1 Health N1 Personnel) OR (Laboratory N1 Proficiency N1 Test*) OR (Near N1 Miss*) OR (Close N1 Call*) OR (PIM N1 List*) OR (Potentially N1 Inappropriate N1 Medication*) OR (Beers N1 Criteria*) OR (Beers N1 Potentially N1 Inappropriate N1 Medication*) OR STOPP OR (Screening N1 Tool N1 of N1 Older N1 Person* N1 Potentially N1 Inappropriate N1 Prescription*))) OR (AB (((care OR healthcare OR (Health N1 Care)) N1 Qualit*) OR ((Institutional OR Protocol OR Policy OR Guideline) N1 (adherence OR Compliance)) OR "Outcome and Process Assessment" OR (Structure N1 Process N1 Outcome N1 Triad*) OR (Donabedian N1 (Model* OR Triad*)) OR (Outcome* N1 (Assessment* OR Research* OR Stud* OR Measure*)) OR (Failure* N1 to N1 Rescue*) OR (Patient N1 Outcome* N1 Assessment*) OR (Patient N1 Centered N1 Outcome* N1 Research) OR (((Patient N1 Relevant) OR Rehabilitation OR Treatment OR (Patient N1 Reported) OR (Critical N1 Care)) N1 Outcome*) OR ((Treatment OR Clinical) N1 (Effectiveness* OR Efficac*)) OR (Treatment N1 Failure*) OR (Process N1 (Assessment* OR Measure*)) OR (((Professional N1 Review) OR (Peer N1 Review) OR (Professional N1 Standards N1 Review)) N1 Organization*) OR PSRO OR "Utilization and Quality Control Peer Review Organizations" OR (Program N1 (Evaluation* OR Sustainabilit* OR Effectiveness OR Appropriateness)) OR (Best N1 Practice N1 Analysis) OR Benchmark* OR (((Health N1 Care N1 Quality) OR (Healthcare N1 Quality)) N1 (Assurance* OR Assessment*)) OR (Alert N1 Fatigue N1 Health N1

Personnel) OR (Laboratory N1 Proficiency N1 Test*) OR (Near N1 Miss*) OR (Close N1 Call*) OR (PIM N1 List*) OR (Potentially N1 Inappropriate N1 Medication*) OR (Beers N1 Criteria*) OR (Beers N1 Potentially N1 Inappropriate N1 Medication*) OR STOPP OR (Screening N1 Tool N1 of N1 Older N1 Person* N1 Potentially N1 Inappropriate N1 Prescription*))) OR (SU (((care OR healthcare OR (Health N1 Care)) N1 Qualit*) OR ((Institutional OR Protocol OR Policy OR Guideline) N1 (adherence OR Compliance)) OR "Outcome and Process Assessment" OR (Structure N1 Process N1 Outcome N1 Triad*) OR (Donabedian N1 (Model* OR Triad*)) OR (Outcome* N1 (Assessment* OR Research* OR Stud* OR Measure*)) OR (Failure* N1 to N1 Rescue*) OR (Patient N1 Outcome* N1 Assessment*) OR (Patient N1 Centered N1 Outcome* N1 Research) OR (((Patient N1 Relevant) OR Rehabilitation OR Treatment OR (Patient N1 Reported) OR (Critical N1 Care)) N1 Outcome*) OR ((Treatment OR Clinical) N1 (Effectiveness* OR Efficac*)) OR (Treatment N1 Failure*) OR (Process N1 (Assessment* OR Measure*)) OR (((Professional N1 Review) OR (Peer N1 Review) OR (Professional N1 Standards N1 Review)) N1 Organization*) OR PSRO OR "Utilization and Quality Control Peer Review Organizations" OR (Program N1 (Evaluation* OR Sustainabilit* OR Effectiveness OR Appropriateness)) OR (Best N1 Practice N1 Analysis) OR Benchmark* OR (((Health N1 Care N1 Quality) OR (Healthcare N1 Quality)) N1 (Assurance* OR Assessment*)) OR (Alert N1 Fatigue N1 Health N1 Personnel) OR (Laboratory N1 Proficiency N1 Test*) OR (Near N1 Miss*) OR (Close N1 Call*) OR (PIM N1 List*) OR (Potentially N1 Inappropriate N1 Medication*) OR (Beers N1 Criteria*) OR (Beers N1 Potentially N1 Inappropriate N1 Medication*) OR STOPP OR (Screening N1 Tool N1 of N1 Older N1 Person* N1 Potentially N1 Inappropriate N1 Prescription*)))

**S12** (MH "Workload") OR (MH "Task Performance and Analysis+") OR (TI ((Task N1 Performance*) OR (Critical N1 Incident N1 Techni*) OR workload* OR (work N1 load*))) OR (AB ((Task N1 Performance*) OR (Critical N1 Incident N1 Techni*) OR workload* OR (work N1 load*))) OR (SU ((Task N1 Performance*) OR (Critical N1 Incident N1 Techni*) OR workload* OR (work N1 load*)))

**S13** (MH "Job Satisfaction+") OR (TI ((Job OR work) N1 Satisfaction)) OR (AB ((Job OR work) N1 Satisfaction)) OR (SU ((Job OR work) N1 Satisfaction))

**S14** (MH "Organizational Efficiency+") OR (TI (efficien*OR inefficien* OR (clinical W1 effective*) OR productiv* OR effective* OR ineffective*)) OR (AB (efficien*OR inefficien* OR (clinical W1 effective*)

OR productiv*)) OR (SU (efficien*OR inefficien* OR (clinical W1 effective*) OR productiv*))

**S15** S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14

**S16** (MH "Clinical Trials+") OR (PT (Clinical trial)) OR (MH "Random Assignment") OR (MH "Quantitative Studies") OR (TX ((clini* N1 trial*) OR ((waitlist* OR (wait* and list*)) and (control* OR group)) OR "treatment as usual" OR tau OR (control* N3 (trial* OR study OR studies OR group*)) OR randomized OR randomised))

**S17** (MH "Prospective Studies+") OR (MH "Double-Blind Studies") OR (MH "Single-Blind Studies") OR (MH "Triple-Blind Studies") OR (TX (cohort* OR ((Concurrent OR Incidence OR Followup* OR Prospective OR Longitudinal OR Retrospective OR (Follow N1 up*)) N1 (Study OR studies)) OR (Longitudinal N1 Surve*) OR (before N1 after)))

**S18** (TX ((multi N1 (center* OR centre*) N1 stud*) OR (multicenter* N1 stud*)))

**S19** S16 OR S17 OR S18

**S20** S1 AND S15 AND S19

**Results: 1,170**

**Cochrane**

**#1** ((physician NEAR/1 (assistant* OR associate* OR extender* OR substitute*)) OR (medical NEAR/1 extender*) OR (advanced NEAR/1 provider*) OR (emergency NEAR/1 practitioner*) OR ((Midlevel OR (mid NEAR/1 level) OR ((non OR none) NEAR/1 physician*) OR nonphysician*) NEAR/2 (clinic* OR ((health OR healthcare) NEAR/2 (professional* OR provider* OR worker*)) OR personnel OR practitioner* OR professional* OR provider* OR staff OR worker* OR specialist* OR (first NEAR/1 assistant*))) OR (midlevel NEAR/1 health NEAR/1 care) OR (advance* NEAR/1 practice NEAR/1 provider*)):ti,ab,kw

**#2** (((Spend* OR Fund* OR Expen* OR Budget*) NEAR/1 (control* OR saving* OR care OR health* OR high OR medical)) OR champus OR (Claim* NEAR/1 (analysis OR review*)) OR Coinsurance* OR (Competitive NEAR/1 (Health* OR medical) NEAR/1 Plan*) OR Costeffect* OR Deductible* OR (direct NEAR/1 cost*) OR (Economic NEAR/1 evaluat*) OR (Health NEAR/1 Benefit* NEAR/1 Plan*) OR insuran* OR (managed NEAR/1 car*) OR medicare OR (Preferred NEAR/1 provider*) OR Reimburs* OR (Third NEAR/1 Party NEAR/1 Pay*) OR (Usage NEAR/1 reduction*) OR (Value NEAR/1 Based NEAR/1

Purchas*) OR (Worker* NEAR/1 Compensation*) OR (Return NEAR/1 on NEAR/1 investment*) OR ROI OR ((Cost OR costs) NEAR/1 (allocat* OR analy* OR apportionment* OR benefit* OR compar* OR contain* OR control* OR decreas* OR effective* OR Efficien* OR evaluat* OR increase* OR manag* OR minimi* OR reduc* OR saving* OR sharing OR shifting* OR minimization OR minimisation OR (health NEAR/1 care) OR health* OR high* OR low* OR increas* OR medical OR rising OR societal OR Treatment))):ti,ab,kw

**#3** (waitlist* OR delist* OR (wait* NEAR/1 (period OR list* OR time))):ti,ab,kw

**#4** (Hospitaliz* OR Hospitalis* OR Admission* OR Discharg* OR Handoff* OR (Hand* NEAR/1 (Over* OR off)) OR (Sign NEAR/1 Out*) OR Signout* OR Handover* OR Readmis* OR ((healthcare OR care OR patient*) NEAR/1 (transfer* OR transition*)) OR (Patient* NEAR/1 (Turfing* OR Dumping*)) OR ((Duration OR Hospital OR Length*) NEAR/1 stay*)):ti,ab,kw

**#5** (Mortalit* OR (Case NEAR/1 Fatality NEAR/1 Rate*) OR (Death NEAR/1 Rate*) OR (Fatal NEAR/1 Outcome*)):ti,ab,kw

**#6** (morbidit* OR comorbidit*):ti,ab,kw

**#7** ((Quality NEAR/1 Adjusted NEAR/1 Years) OR QALY OR (Healthy NEAR/1 Year* NEAR/1 Equivalent*) OR (Adjusted NEAR/1 Life NEAR/1 Year*) OR (life NEAR/1 qualit*) OR (quality NEAR/1 of NEAR/1 life) OR (health NEAR/1 status) OR (level NEAR/1 of NEAR/1 health) OR (health NEAR/1 level*) OR qol OR hrql OR hrqol OR (activit* NEAR/1 of NEAR/1 daily NEAR/1 living) OR (daily NEAR/1 activit*) OR adl OR (chronic NEAR/1 limitation NEAR/1 of NEAR/1 activit*)):ti,ab,kw

**#8** (Patient* NEAR/1 (Satisfaction* OR preference* OR experienc*)):ti,ab,kw

**#9** ((medication OR Therapeutic OR Treatment OR Patient*) NEAR/1 (Adher* OR Cooperat* OR ((Non OR none) NEAR/1 (Compli* OR adher*)) OR Nonadher* OR Noncompli*)):ti,ab,kw

**#10** ((Wrong NEAR/1 Procedure*) OR (Wrong NEAR/1 Site NEAR/1 Surger*) OR ((Surgical OR Medical OR Diagnostic) NEAR/1 (Mistake* OR Error*)) OR (Critical NEAR/1 Medical NEAR/1 Incident*) OR (Never NEAR/1 Event*) OR Misdiagnos* OR (False NEAR/1 (Negative OR positive) NEAR/1 Reaction*) OR ((Intraobserver OR Interobserver OR Observer*) NEAR/1 (Variation* OR bias OR Variabilit*)) OR ("Near" NEAR/1 Miss*) OR (Close NEAR/1 Call*) OR (Radiotherapy NEAR/1 Setup NEAR/1 Error*) OR ((Medication

OR (Drug NEAR/1 Use)) NEAR/1 Error*) OR (patient* NEAR/1 safet*)):ti,ab,kw

**#11** (((care OR healthcare OR (Health NEAR/1 Care)) NEAR/1 Qualit*) OR ((Institutional OR Protocol OR Policy OR Guideline) NEAR/1 (adherence OR Compliance)) OR "Outcome and Process Assessment" OR (Structure NEAR/1 Process NEAR/1 Outcome NEAR/1 Triad*) OR (Donabedian NEAR/1 (Model* OR Triad*)) OR (Outcome* NEAR/1 (Assessment* OR Research* OR Stud* OR Measure*)) OR (Failure* NEAR/1 to NEAR/1 Rescue*) OR (Patient NEAR/1 Outcome* NEAR/1 Assessment*) OR (Patient NEAR/1 (Centered OR centred) NEAR/1 Outcome* NEAR/1 Research) OR (((Patient NEAR/1 Relevant) OR Rehabilitation OR Treatment OR (Patient NEAR/1 Reported) OR (Critical NEAR/1 Care)) NEAR/1 Outcome*) OR ((Treatment OR Clinical) NEAR/1 (Effectiveness* OR Efficac*)) OR (Treatment NEAR/1 Failure*) OR (Process NEAR/1 (Assessment* OR Measure*)) OR (((Professional NEAR/1 Review*) OR (Peer NEAR/1 Review*) OR (Professional NEAR/1 Standards NEAR/1 Review*)) NEAR/1 Organization*) OR PSRO OR "Utilization and Quality Control Peer Review Organizations" OR (Program* NEAR/1 (Evaluation* OR Sustainabilit* OR Effectiveness OR Appropriateness)) OR (Best NEAR/1 Practice NEAR/1 Analysis) OR Benchmark* OR (((Health NEAR/1 Care NEAR/1 Quality) OR (Healthcare NEAR/1 Quality)) NEAR/1 (Assurance* OR Assessment*)) OR (Alert NEAR/1 Fatigue NEAR/1 Health NEAR/1 Personnel) OR (Laboratory NEAR/1 Proficiency NEAR/1 Test*) OR (Close NEAR/1 Call*) OR (PIM NEAR/1 List*) OR (Potentially NEAR/1 Inappropriate NEAR/1 Medication*) OR (Beers NEAR/1 Criteria*) OR (Beers NEAR/1 Potentially NEAR/1 Inappropriate NEAR/1 Medication*) OR STOPP OR (Screening NEAR/1 Tool NEAR/1 of NEAR/1 Older NEAR/1 Person* NEAR/1 Potentially NEAR/1 Inappropriate NEAR/1 Prescription*)):ti,ab,kw

**#12** ((Task NEAR/1 Performance*) OR (Critical NEAR/1 Incident* NEAR/1 Techni*) OR workload* OR (work NEAR/1 load*)):ti,ab,kw

**#13** ((Job OR work) NEAR/1 Satisfaction):ti,ab,kw

**#14** (effective* OR ineffective*):ti

**#15** (efficien*OR inefficien* OR (clinical NEAR/1 effective*) OR productiv*):ti,ab,kw

**#16** #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15

**#17** ((clini* NEAR/1 trial*) OR ((waitlist* OR (wait* and list*)) and (control* OR group)) OR "treatment as usual" OR tau OR (control*

NEAR/3 (trial* OR study OR studies OR group*)) OR randomized OR randomised)

**#18** (cohort* OR ((Concurrent OR Incidence OR Followup* OR Prospective OR Longitudinal OR Retrospective OR (Follow NEAR/1 up*)) NEAR/1 (Study OR studies)) OR (Longitudinal NEAR/1 Surve*) OR (before NEAR/1 after))

**#19** ((multi NEAR/1 (center* OR centre*) NEAR/1 stud*) OR (multicenter* NEAR/1 stud*))

**#20** #17 OR #18 OR #19

**#21** #1 AND #16 AND #20

**Results: 414**

**Embase**

**1** physician assistant/ or ((physician adj1 (associate or associates or extender* or substitute*)) or "physician assistant" or "physician assistants" or (advance* adj1 provider*) or (emergency adj1 practitioner*) or ((Midlevel or (mid adj1 level) or ((non or none) adj1 physician*) or nonphysician*) adj2 (clinician* or professional* or provider* or worker* or personnel or practitioner* or professional* or provider* or staff or worker* or specialist* or (first adj1 assistant*))) or (advance* adj1 practice adj1 provider*)).ti,ab,kw.

**2** health economics/ or exp economic evaluation/ or exp "health care cost"/ or exp health insurance/ OR patient referral/ OR (((Spend* OR Fund* OR Expen* OR Budget*) ADJ1 (control* OR saving* OR care OR health* OR high OR medical)) OR champus OR (Claim* ADJ1 (analysis OR review*)) OR Coinsurance* OR (Competitive ADJ1 (Health* OR medical) ADJ1 Plan*) OR Costeffect* OR Deductible* OR (direct ADJ1 cost*) OR (Economic ADJ1 evaluat*) OR (Health ADJ1 Benefit* ADJ1 Plan*) OR insuran* OR (managed ADJ1 car*) OR medicare OR (Preferred ADJ1 provider*) OR Reimburs* OR (Third ADJ1 Party ADJ1 Pay*) OR (Usage ADJ1 reduction*) OR (Value ADJ1 Based ADJ1 Purchas*) OR (Worker* ADJ1 Compensation*) OR (Return ADJ1 on ADJ1 investment*) OR ROI OR ((Cost OR costs) ADJ1 (allocat* OR analy* OR apportionment* OR benefit* OR compar* OR contain* OR control* OR decreas* OR effective* OR Efficien* OR evaluat* OR increase* OR manag* OR minimi* OR reduc* OR saving* OR sharing OR shifting* OR minimization OR minimisation OR (health ADJ1 care) OR health* OR high* OR low* OR increas* OR medical OR rising OR societal OR Treatment))).ti,ab,kw.

**3** (waitlist* OR delist* OR (wait* ADJ1 (period OR list* OR time))).ti,ab,kw.

**4** hospitalization/ OR Diagnosis Related Group/ OR length of stay/ OR patient dumping/ OR hospital readmission/ OR (Hospitaliz* OR Hospitalis* OR Admission* OR Discharg* OR Handoff* OR (Hand* ADJ1 (Over* OR off)) OR (Sign ADJ1 Out*) OR Signout* OR Handover* OR Readmis* OR ((healthcare OR care OR patient*) ADJ1 (transfer* OR transition*)) OR (Patient* ADJ1 (Turfing* OR Dumping*)) OR ((Duration OR Hospital OR Length*) ADJ1 stay*)).ti,ab,kw.

**5** exp mortality/ OR (Mortalit* OR (Case ADJ1 Fatality ADJ1 Rate*) OR (Death ADJ1 Rate*) OR (Fatal ADJ1 Outcome*)).ti,ab,kw.

**6** morbidity/ OR (morbidit* OR comorbidit*).ti,ab,kw.

**7** exp quality of life/ OR exp health status/ OR exp activity of daily living assessment/ OR ((Quality ADJ1 Adjusted ADJ1 Years) OR QALY OR (Healthy ADJ1 Year* ADJ1 Equivalent*) OR (Adjusted ADJ1 Life ADJ1 Year*) OR (life ADJ1 qualit*) OR (quality ADJ1 of ADJ1 life) OR (health ADJ1 status) OR (level ADJ1 of ADJ1 health) OR (health ADJ1 level*) OR qol OR hrql OR hrqol OR (activit* ADJ1 of ADJ1 daily ADJ1 living) OR (daily ADJ1 activit*) OR adl OR (chronic ADJ1 limitation ADJ1 of ADJ1 activit*)).ti,ab,kw.

**8** patient satisfaction/ OR (Patient* ADJ1 (Satisfaction* OR preference* OR experienc*)).ti,ab,kw.

**9** exp Patient Compliance/ OR ((medication OR Therapeutic OR Treatment OR Patient*) ADJ1 (Adher* OR Cooperat* OR ((Non OR none) ADJ1 (Compli* OR adher*)) OR Nonadher* OR Noncompli*)). ti,ab,kw.

**10** exp patient safety/ or sentinel event/ or ((Wrong adj1 Procedure*) or (Wrong adj1 Site adj1 Surger*) or ((Surgical or Medical or Diagnostic) adj1 (Mistake* or Error*)) or (Critical adj1 Medical adj1 Incident*) or (Never adj1 Event*) or Misdiagnos* or (False adj1 (Negative or positive) adj1 Reaction*) or ((Intraobserver or Interobserver or Observer*) adj1 (Variation* or bias or Variabilit*)) or (Near adj1 Miss*) or (Close adj1 Call*) or (Radiotherapy adj1 Setup adj1 Error*) or ((Medication or (Drug adj1 "use")) adj1 Error*) or (patient* adj1 safet*)).ti,ab,kw.

**11** exp Health Care quality/ OR (((care OR healthcare OR (Health ADJ1 Care)) ADJ1 Qualit*) OR ((Institutional OR Protocol OR Policy OR Guideline) ADJ1 (adherence OR Compliance)) OR "Outcome and Process Assessment" OR (Structure ADJ1 Process ADJ1 Outcome ADJ1 Triad*) OR (Donabedian ADJ1 (Model* OR Triad*)) OR (Outcome* ADJ1 (Assessment* OR Research* OR Stud* OR Measure*)) OR (Failure* ADJ1 to ADJ1 Rescue*) OR (Patient ADJ1 Outcome* ADJ1 Assessment*) OR (Patient ADJ1 (Centered OR centred) ADJ1 Outcome* ADJ1 Research) OR (((Patient ADJ1 Relevant) OR Rehabilitation OR Treatment OR (Patient ADJ1 Reported) OR (Critical ADJ1 Care)) ADJ1

Outcome*) OR ((Treatment OR Clinical) ADJ1 (Effectiveness* OR Efficac*)) OR (Treatment ADJ1 Failure*) OR (Process ADJ1 (Assessment* OR Measure*)) OR (((Professional ADJ1 Review*) OR (Peer ADJ1 Review*) OR (Professional ADJ1 Standards ADJ1 Review*)) ADJ1 Organization*) OR PSRO OR "Utilization and Quality Control Peer Review Organizations" OR (Program* ADJ1 (Evaluation* OR Sustainabilit* OR Effectiveness OR Appropriateness)) OR (Best ADJ1 Practice ADJ1 Analysis) OR Benchmark* OR (((Health ADJ1 Care ADJ1 Quality) OR (Healthcare ADJ1 Quality)) ADJ1 (Assurance* OR Assessment*)) OR (Alert ADJ1 Fatigue ADJ1 Health ADJ1 Personnel) OR (Laboratory ADJ1 Proficiency ADJ1 Test*) OR (Close ADJ1 Call*) OR (PIM ADJ1 List*) OR (Potentially ADJ1 Inappropriate ADJ1 Medication*) OR (Beers ADJ1 Criteria*) OR (Beers ADJ1 Potentially ADJ1 Inappropriate ADJ1 Medication*) OR STOPP OR (Screening ADJ1 Tool ADJ1 of ADJ1 Older ADJ1 Person* ADJ1 Potentially ADJ1 Inappropriate ADJ1 Prescription*)).ti,ab,kw.

**12** Workload/ OR ((Task ADJ1 Performance*) OR (Critical ADJ1 Incident* ADJ1 Techni*) OR workload* OR (work ADJ1 load*)).ti,ab,kw.

**13** Job Satisfaction/ OR ((Job OR work) ADJ1 Satisfaction).ti,ab,kw.

**14** (effective* OR ineffective*).ti.

**15** (efficien*OR inefficien* OR (clinical ADJ1 effective*) OR productiv*).ti,ab,kw.

**16** 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15

**17** exp controlled clinical trial/ OR ((clini* ADJ1 trial*) OR ((waitlist* OR (wait* and list*)) and (control* OR group)) OR "treatment as usual" OR tau OR (control* ADJ3 (trial* OR study OR studies OR group*)) OR randomized OR randomized OR groups).ti,ab,kw,pt.

**18** cohort analysis/ OR (cohort* OR ((Concurrent OR Incidence OR Followup* OR Prospective OR Longitudinal OR Retrospective OR (Follow ADJ1 up*)) ADJ1 (Study OR studies)) OR (Longitudinal ADJ1 Surve*) OR (before ADJ1 after)).ti,ab,kw,pt.

**19** ((multi ADJ1 (center* OR centre*) ADJ1 stud*) OR (multicenter* ADJ1 stud*)).ti,ab,kw,pt.

**20** 17 OR 18 OR 19

**21** 1 AND 16 AND 20

**22** limit 21 to conference abstract status

**23** 21 NOT 22

**Results: 1,090**

**PubMed**

**#1** "Physician Assistants"[mesh] OR physician assistant*[tiab] OR physician associate[tiab] OR physician associates[tiab] OR physician extender*[tiab] OR physicians assistant*[tiab] OR physicians extender*[tiab] OR physician substitute*[tiab] OR advanced providers[tiab] OR emergency practitioner*[tiab] OR mid level clinicians[tiab] OR mid level health care professionals[tiab] OR mid level health care provider*[tiab] OR mid level health care workers[tiab] OR mid level health professionals[tiab] OR mid level health providers[tiab] OR mid level health workers[tiab] OR mid level healthcare workers[tiab] OR mid level medical workers[tiab] OR mid level personnel[tiab] OR mid level practitioners[tiab] OR mid level professionals[tiab] OR mid level provider[tiab] OR mid level staff[tiab] OR mid level workers[tiab] OR midlevel clinician*[tiab] OR midlevel health care professional*[tiab] OR midlevel health care provider*[tiab] OR midlevel health care[tiab] OR midlevel health provider*[tiab] OR midlevel health worker*[tiab] OR midlevel personnel[tiab] OR midlevel practitioner*[tiab] OR midlevel professional*[tiab] OR midlevel provider*[tiab] OR non physician clinic staff[tiab] OR non physician clinicians[tiab] OR non physician first assistants[tiab] OR non physician health care personnel[tiab] OR non physician health care professionals[tiab] OR non physician health care providers[tiab] OR non physician health care workers[tiab] OR non physician health professionals[tiab] OR non physician health providers[tiab] OR non physician health workers[tiab] OR non physician healthcare professionals[tiab] OR non physician healthcare providers[tiab] OR non physician healthcare workers[tiab] OR non physician medical personnel[tiab] OR non physician personnel[tiab] OR non physician practice staff[tiab] OR non physician primary care providers[tiab] OR non physician professionals[tiab] OR non physician provider[tiab] OR non physician providers[tiab] OR nonphysician clinic*[tiab] OR nonphysician medical personnel[tiab] OR nonphysician personnel[tiab] OR nonphysician practitioner*[tiab] OR nonphysician primary care clinicians[tiab] OR nonphysician primary care providers[tiab] OR nonphysician specialists[tiab] OR nonphysician staff[tiab] OR advanced practice provider*[tiab] OR advance practice provider*[tiab] OR medical extender*[tiab]

**#2** "costs and cost analysis"[mesh] OR "cost of illness"[mesh] OR "Health Care Costs"[Mesh] OR "Insurance"[Mesh] OR "Referral and Consultation"[Mesh] OR Budget control*[tiab] OR Budget saving*[tiab] OR Care budget*[tiab] OR care expen*[tiab] OR Care expen*[tiab] OR Care fund*[tiab] OR Care spend*[tiab] OR champus[tiab] OR Claim analysis[tiab] OR Claim review*[tiab] OR Claims Analysis[tiab] OR

Claims Review*[tiab] OR Coinsurance*[tiab] OR Competitive Health Plan*[tiab] OR Competitive Medical Plan*[tiab] OR control cost*[tiab] OR Cost allocat*[tiab] OR Cost analy*[tiab] OR Cost apportionment*[tiab] OR Cost benefit*[tiab] OR Cost compar*[tiab] OR Cost contain*[tiab] OR Cost control*[tiab] OR Cost decreas*[tiab] OR Cost effective*[tiab] OR Cost Efficien*[tiab] OR Cost evaluat*[tiab] OR Cost increase*[tiab] OR Cost manag*[tiab] OR Cost minimi*[tiab] OR Cost reduc*[tiab] OR Cost reduction[tiab] OR Cost saving*[tiab] OR Cost sharing[tiab] OR Cost shifting*[tiab] OR Costeffect*[tiab] OR Cost minimisation[tiab] OR Cost minimization[tiab] OR Deductible*[tiab] OR direct cost*[tiab] OR Economic evaluat*[tiab] OR Health Benefit Plan*[tiab] OR Health budget*[tiab] OR health care cost*[tiab] OR Health care saving*[tiab] OR health care spending[tiab] OR health cost*[tiab] OR health expen*[tiab] OR health expenditure*[tiab] OR Health fund*[tiab] OR Health spend*[tiab] OR health spending*[tiab] OR Healthcare budget*[tiab] OR Healthcare cost*[tiab] OR healthcare expen*[tiab] OR Healthcare fund*[tiab] OR Healthcare savings[tiab] OR Healthcare spend*[tiab] OR healthcare spending*[tiab] OR High cost*[tiab] OR High spend*[tiab] OR Increasing cost*[tiab] OR insuran*[tiab] OR Low cost*[tiab] OR managed car*[tiab] OR Medical budget*[tiab] OR Medical Care Cost*[tiab] OR medical cost*[tiab] OR Medical expen*[tiab] OR Medical fund*[tiab] OR medical saving*[tiab] OR Medical saving*[tiab] OR Medical spend*[tiab] OR medicare[tiab] OR Preferred provider*[tiab] OR Reducing cost*[tiab] OR Reimburs*[tiab] OR Rising cost*[tiab] OR Saving cost*[tiab] OR societal cost*[tiab] OR Third-Party Pay*[tiab] OR Treatment Cost*[tiab] OR Usage reduction*[tiab] OR Value Based Purchas*[tiab] OR Worker Compensation*[tiab] OR Worker s compensation*[tiab] OR Workers compensation*[tiab] OR Return on investment*[tiab] OR ROI[tiab]

**#3** "Waiting Lists"[Mesh] OR waiting list*[tiab] OR waitlist*[tiab] OR waitlist*[tiab] OR delist*[tiab] OR wait period*[tiab] OR waiting period*[tiab] OR waiting time*[tiab] OR wait time*[tiab]

**#4** "Hospitalization"[Mesh] OR Hospitaliz*[tiab] OR Hospitalis*[tiab] OR Admission*[tiab] OR Discharg*[tiab] OR Handoff*[tiab] OR Hand Over*[tiab] OR Sign Out*[tiab] OR Signout*[tiab] OR Hand Off*[tiab] OR Handover*[tiab] OR Readmis*[tiab] OR Patient Transfer*[tiab] OR Patient Transition*[tiab] OR Care Transition*[tiab] OR Transition of Care*[tiab] OR Health Care Transition*[tiab] OR Healthcare transition*[tiab] OR Patient Turfing*[tiab] OR Patient Dumping*[tiab] OR length of stay*[tiab] OR Stay Length[tiab] OR Hospital Stay*[tiab] OR duration of stay*[tiab] OR lengths of stay*[tiab]

**#5** "Mortality"[Mesh] OR "mortality" [Subheading] OR Mortalit*[tiab] OR Case Fatality Rate*[tiab] OR Death Rate*[tiab] OR Fatal Outcome*[tiab]

**#6** "Morbidity"[Mesh] OR morbidit*[tiab] OR comorbidit*[tiab]

**#7** "Quality of Life"[Mesh] OR "Health Status"[Mesh] OR "Activities of Daily Living"[Mesh] OR "Quality-Adjusted Life Years"[Mesh] OR Quality Adjusted Life Years[tiab] OR QALY[tiab] OR Healthy Years Equivalent*[tiab] OR Adjusted Life Year*[tiab] OR life qualit*[tiab] OR quality of life[tiab] OR health status[tiab] OR level of health[tiab] OR health level*[tiab] OR qol[tiab] OR hrql[tiab] OR hrqol[tiab] OR activities of daily living[tiab] OR daily living activit*[tiab] OR adl[tiab] OR chronic limitation of activit*[tiab]

**#8** "Patient Satisfaction"[Mesh] OR Patient Satisfaction*[tiab] OR Patient preference*[tiab] OR patient experienc*[tiab] OR satisfaction of patient*[tiab]

**#9** "Patient Compliance"[Mesh:NoExp] OR "Medication Adherence"[Mesh] OR Patient Adher*[tiab] OR Patient Cooperat*[tiab] OR Patient Non-Compli*[tiab] OR Patient Nonadher*[tiab] Patient Noncompli*[tiab] OR Patient Non Adher*[tiab] OR Treatment Complianc*[tiab] OR Therapeutic Complianc*[tiab] OR Medication Nonadher*[tiab] OR Medication Noncomplianc*[tiab] OR Medication Non Adher*[tiab] OR Medication Persistence*[tiab] OR Medication Complianc*[tiab] OR Medication Non Complianc*[tiab]

**#10** "Patient Safety"[Mesh] OR "Medical Errors"[Mesh] OR Medical Mistake*[tiab] OR Medical Error*[tiab] OR Wrong-Procedure Error*[tiab] OR Wrong-Site Surger*[tiab] OR Surgical Error*[tiab] OR Critical Medical Incident*[tiab] OR Never Event*[tiab] OR Diagnostic Error*[tiab] OR Misdiagnos*[tiab] OR False Negative Reaction*[tiab] OR False Positive Reaction*[tiab] OR Observer Variation*[tiab] OR Observer Bias[tiab] OR Interobserver Variation*[tiab] OR Inter-Observer Variation*[tiab] OR Interobserver Variabilit*[tiab] OR Inter-Observer Variabilit*[tiab] OR Intraobserver Variation*[tiab] OR Intra-Observer Variation*[tiab] OR Intraobserver Variabilit*[tiab] OR Intra Observer Variabilit*[tiab] OR Near Miss*[tiab] OR Close Call*[tiab] OR Radiotherapy Setup Error*[tiab] OR Medication Error*[tiab] OR Drug Use Error*[tiab] OR patient safet*[tiab]

**#11** "Quality of Health Care"[mesh] OR Health Care Qualit*[tiab] OR Quality of Healthcare[tiab] OR Healthcare Quality[tiab] OR Quality of Care[tiab] OR Care Qualit*[tiab] OR Guideline adherence[tiab] OR Policy Compliance[tiab] OR Protocol Compliance[tiab] OR Institutional Adherence[tiab] OR "Outcome and Process Assessment"[tiab] OR

Structure Process Outcome Triad*[tiab] OR Donabedian Model[tiab] OR Donabedian Triad[tiab] OR Outcomes Assessment*[tiab] OR Outcome Assessment*[tiab] OR Outcomes Research[tiab] OR Outcome Stud*[tiab] OR Outcome Measure*[tiab] OR Failure to Rescue*[tiab] OR Failures to Rescue*[tiab] OR Patient Outcome Assessment*[tiab] OR Patient Centered Outcomes Research[tiab] OR Critical Care Outcome*[tiab] OR Patient Reported Outcome*[tiab] OR Treatment outcome*[tiab] OR Patient Relevant Outcome*[tiab] OR Clinical Efficac*[tiab] OR Treatment Effectiveness[tiab] OR Treatment Efficac*[tiab] OR Rehabilitation Outcome*[tiab] OR Treatment Failure*[tiab] OR Process Assessment*[tiab] OR Process Measure*[tiab] OR Professional Review Organization*[tiab] OR Professional Standards Review Organization*[tiab] OR PSRO[tiab] OR Peer Review Organization*[tiab] OR "Utilization and Quality Control Peer Review Organizations"[tiab] OR Program Evaluation*[tiab] OR Program Sustainabilit*[tiab] OR Program Effectiveness[tiab] OR Program Appropriateness[tiab] OR Best Practice Analysis[tiab] OR Benchmark*[tiab] OR Healthcare Quality Assurance*[tiab] OR Health Care Quality Assurance*[tiab] OR Healthcare Quality Assessment*[tiab] OR Health Care Quality Assessment*[tiab] OR Alert Fatigue Health Personnel[tiab] OR Laboratory Proficiency Test*[tiab] OR Near Miss*[tiab] OR Close Call*[tiab] OR PIM List*[tiab] OR Potentially Inappropriate Medication*[tiab] OR Beers Criteria*[tiab] OR Beers Potentially Inappropriate Medications[tiab] OR STOPP[tiab] OR Screening Tool of Older Person's Potentially Inappropriate Prescription*[tiab]

**#12** "Workload"[Mesh] OR "Task Performance and Analysis"[Mesh] OR Task Performance*[tiab] OR Critical Incident Techni*[tiab] OR workload*[tiab] OR work load*[tiab]

**#13** "Job Satisfaction"[Mesh] OR Job Satisfaction[tiab] OR work Satisfaction[tiab]

**#14** Efficiency[mesh] OR efficien*[tiab] OR inefficien*[tiab] OR clinical effective*[tiab] OR productiv*[tiab] OR effective*[ti] OR ineffective*[ti]

**#15** #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14

**#16** randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR randomised[tiab] OR drug therapy[sh] OR randomly[tiab] OR trial[tiab] OR groups[tiab]

**#17** "Cohort Studies"[Mesh] OR cohort*[tiab] OR Concurrent Stud*[tiab] OR Incidence Stud*[tiab] OR Followup Stud*[tiab] OR Follow up Stud*[tiab] OR Longitudinal Stud*[tiab] OR Longitudinal

Surve*[tiab] OR Prospective Stud*[tiab] OR Retrospective Stud*[tiab] OR before after[tiab]

**#18** multi center stud*[tiab] OR multi centre stud*[tiab] OR multicenter stud*[tiab] OR multi centre stud*[tiab]

**#19** #16 OR #17 OR #18

**#20** #1 AND #15 AND #19

**Results: 1,657**

**WOS**

**#1** TS=((“physician” NEAR/1 (assistant* OR “associate” OR “associates” OR extender* OR substitute*)) OR (medical NEAR/1 extender*) OR (advance* NEAR/1 provider*) OR (“emergency” NEAR/0 practitioner*) OR ((“Midlevel” OR (“mid” NEAR/1 “level”) OR ((“non” OR “none”) NEAR/1 physician*) OR nonphysician*) NEAR/2 (clinician* OR ((“health” OR “healthcare”) NEAR/2 (professional* OR provider* OR worker*)) OR “personnel” OR practitioner* OR professional* OR provider* OR “staff” OR worker* OR specialist* OR (“first” NEAR/1 assistant*))) OR (“midlevel” NEAR/1 “health” NEAR/1 “care”) OR (advance* NEAR/1 “practice” NEAR/1 provider*))

**#2** TS=(((Spend* OR Fund* OR Expen* OR Budget*) NEAR/1 (control* OR saving* OR “care” OR health* OR “high” OR “medical”)) OR “champus” OR (Claim* NEAR/1 (“analysis” OR review*)) OR Coinsurance* OR (“Competitive” NEAR/1 (Health* OR “medical”) NEAR/1 Plan*) OR Costeffect* OR Deductible* OR (“direct” NEAR/1 cost*) OR (“Economic” NEAR/1 evaluat*) OR (“Health” NEAR/1 Benefit* NEAR/1 Plan*) OR insuran* OR (“managed” NEAR/1 car*) OR “medicare” OR (“Preferred” NEAR/1 provider*) OR Reimburs* OR (“Third” NEAR/1 “Party” NEAR/1 Pay*) OR (“Usage” NEAR/1 reduction*) OR (“Value” NEAR/1 “Based” NEAR/1 Purchas*) OR (Worker* NEAR/1 Compensation*) OR (“Return” NEAR/1 “on” NEAR/1 investment*) OR “ROI” OR ((“Cost” OR “costs”) NEAR/1 (allocat* OR analy* OR apportionment* OR benefit* OR compar* OR contain* OR control* OR decreas* OR effective* OR Efficien* OR evaluat* OR increase* OR manag* OR minimi* OR reduc* OR saving* OR “sharing” OR shifting* OR “minimization” OR “minimization” OR (“health” NEAR/1 “care”) OR health* OR high* OR low* OR increas* OR “medical” OR “rising” OR “societal” OR “Treatment”)))

**#3** TS=(waitlist* OR delist* OR (wait* NEAR/1 (“period” OR list* OR “time”)))

**#4** TS=(Hospitaliz* OR Hospitalis* OR Admission* OR Discharg* OR Handoff* OR (Hand* NEAR/1 (Over* OR "off")) OR ("Sign" NEAR/1 Out*) OR Signout* OR Handover* OR Readmis* OR (("healthcare" OR "care" OR patient*) NEAR/1 (transfer* OR transition*)) OR (Patient* NEAR/1 (Turfing* OR Dumping*)) OR (("Duration" OR "Hospital" OR Length*) NEAR/1 stay*))

**#5** TS=(Mortalit* OR ("Case" NEAR/1 "Fatality" NEAR/1 Rate*) OR ("Death" NEAR/1 Rate*) OR ("Fatal" NEAR/1 Outcome*))

**#6** TS=(morbidit* OR comorbidit*)

**#7** TS=(("Quality" NEAR/1 "Adjusted" NEAR/1 Years) OR "QALY" OR ("Healthy" NEAR/1 Year* NEAR/1 Equivalent*) OR ("Adjusted" NEAR/1 "Life" NEAR/1 Year*) OR ("life" NEAR/1 qualit*) OR ("quality" NEAR/1 "of" NEAR/1 "life") OR ("health" NEAR/1 "status") OR ("level" NEAR/1 "of" NEAR/1 "health") OR ("health" NEAR/1 level*) OR "qol" OR "hrql" OR "hrqol" OR (activit* NEAR/1 "of" NEAR/1 "daily" NEAR/1 "living") OR ("daily" NEAR/1 activit*) OR "adl" OR ("chronic" NEAR/1 "limitation" NEAR/1 "of" NEAR/1 activit*))

**#8** TS=(Patient* NEAR/1 (Satisfaction* OR preference* OR experienc*))

**#9** TS=(("medication" OR "Therapeutic" OR "Treatment" OR Patient*) NEAR/1 (Adher* OR Cooperat* OR (("Non" OR "none") NEAR/1 (Compli* OR adher*)) OR Nonadher* OR Noncompli*))

**#10** TS=(("Wrong" NEAR/1 Procedure*) OR ("Wrong" NEAR/1 "Site" NEAR/1 Surger*) OR (("Surgical" OR "Medical" OR "Diagnostic") NEAR/1 (Mistake* OR Error*)) OR ("Critical" NEAR/1 "Medical" NEAR/1 Incident*) OR ("Never" NEAR/1 Event*) OR Misdiagnos* OR ("False" NEAR/1 ("Negative" OR "positive") NEAR/1 Reaction*) OR (("Intraobserver" OR "Interobserver" OR Observer*) NEAR/1 (Variation* OR "bias" OR Variabilit*)) OR ("Near" NEAR/1 Miss*) OR ("Close" NEAR/1 Call*) OR ("Radiotherapy" NEAR/1 "Setup" NEAR/1 Error*) OR (("Medication" OR ("Drug" NEAR/1 "Use")) NEAR/1 Error*) OR (patient* NEAR/1 safet*))

**#11** TS=(((("care" OR "healthcare" OR ("Health" NEAR/1 "Care")) NEAR/1 Qualit*) OR (("Institutional" OR "Protocol" OR "Policy" OR "Guideline") NEAR/1 ("adherence" OR "Compliance")) OR "Outcome and Process Assessment" OR ("Structure" NEAR/1 "Process" NEAR/1 "Outcome" NEAR/1 Triad*) OR ("Donabedian" NEAR/1 (Model* OR Triad*)) OR (Outcome* NEAR/1 (Assessment* OR Research* OR Stud* OR Measure*)) OR (Failure* NEAR/1 "to" NEAR/1 Rescue*) OR ("Patient" NEAR/1 Outcome* NEAR/1 Assessment*) OR

("Patient" NEAR/1 ("Centered" OR "centred") NEAR/1 Outcome* NEAR/1 "Research") OR (((("Patient" NEAR/1 "Relevant") OR "Rehabilitation" OR "Treatment" OR ("Patient" NEAR/1 "Reported") OR ("Critical" NEAR/1 "Care")) NEAR/1 Outcome*) OR (("Treatment" OR "Clinical") NEAR/1 (Effectiveness* OR Efficac*)) OR ("Treatment" NEAR/1 Failure*) OR ("Process" NEAR/1 (Assessment* OR Measure*)) OR ((("Professional" NEAR/1 Review*) OR ("Peer" NEAR/1 Review*) OR ("Professional" NEAR/1 "Standards" NEAR/1 Review*)) NEAR/1 Organization*) OR "PSRO" OR "Utilization and Quality Control Peer Review Organizations" OR (Program* NEAR/1 (Evaluation* OR Sustainabilit* OR "Effectiveness" OR "Appropriateness")) OR ("Best" NEAR/1 "Practice" NEAR/1 "Analysis") OR Benchmark* OR ((("Health" NEAR/1 "Care" NEAR/1 "Quality") OR ("Healthcare" NEAR/1 "Quality")) NEAR/1 (Assurance* OR Assessment*)) OR ("Alert" NEAR/1 "Fatigue" NEAR/1 "Health" NEAR/1 "Personnel") OR ("Laboratory" NEAR/1 "Proficiency" NEAR/1 Test*) OR ("Close" NEAR/1 Call*) OR ("PIM" NEAR/1 List*) OR ("Potentially" NEAR/1 "Inappropriate" NEAR/1 Medication*) OR ("Beers" NEAR/1 Criteria*) OR ("Beers" NEAR/1 "Potentially" NEAR/1 "Inappropriate" NEAR/1 Medication*) OR "STOPP" OR ("Screening" NEAR/1 "Tool" NEAR/1 "of" NEAR/1 "Older" NEAR/1 Person* NEAR/1 "Potentially" NEAR/1 "Inappropriate" NEAR/1 Prescription*))

**#12** TS=(("Task" NEAR/1 Performance*) OR ("Critical" NEAR/1 Incident* NEAR/1 Techni*) OR workload* OR ("work" NEAR/1 load*))

**#13** TS=(("Job" OR "work") NEAR/1 "Satisfaction")

**#14** #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13

**#15** TS=((clini* NEAR/1 trial*) OR (singl* NEAR/1 blind*) OR (singl* NEAR/1 mask*) OR (doubl* NEAR/1 blind*) OR (doubl* NEAR/1 mask*) OR (tripl* NEAR/1 blind*) OR (tripl* NEAR/1 mask*) OR (random* NEAR/1 allocat*) OR placebo* OR ((waitlist* OR (wait* and list*)) and (control* OR "group")) OR "treatment as usual" OR "tau" OR (control* N3 (trial* OR "study" OR "studies" OR group*)) OR "randomized" OR "randomized")

**#16** TS=(cohort* OR (("Concurrent" OR "Incidence" OR Followup* OR "Prospective" OR "Longitudinal" OR "Retrospective" OR ("Follow" NEAR/1 "up")) NEAR/1 ("Study" OR "studies")) OR ("Longitudinal" NEAR/1 Surve*) OR ("before" NEAR/1 "after"))

**#17** TS=(("multi" NEAR/1 (center* OR centre*) NEAR/1 stud*) OR (multicenter* NEAR/1 stud*))

**#18** #15 OR #16 OR #17

**#19** #1 AND #14 AND #18

**#20** TS=(efficien*OR inefficien* OR ("clinical" NEAR/1 effective*) OR productiv* OR effective* OR ineffective*)

**#21** #19 OR #21

**Results: 524**

# 3

# An Activity Analysis of Dutch Hospital-Based Physician Assistants and Nurse Practitioners

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## Abstract

**Background:** The physician assistant (PA) and the nurse practitioner (NP) were introduced into The Netherlands in 2001 and 1997 respectively. By the second decade, national policies had accelerated the acceptance and development of these professions. Since 2015, the PA and NP have full practice authority as independent health professionals. The aim of this research was to gain a better understanding of the tasks and responsibilities that are being shifted from Medical Doctors (MD) to PAs and NPs in hospitals. More specifically in what context and visibility are these tasks undertaken by hospital-based PAs and NPs in patient care. This will enable them to communicate their worth to the hospital management.

**Study design:** A descriptive, non-experimental research method design was used to collect and analyze both quantitative and qualitative data about the type of tasks performed by a PA or NP. Fifteen medical departments across four hospitals participated.

**Methods:** The patient scheduling system and hospital information system were probed to identify and characterize a wide variety of clinical tasks. The array of tasks was further verified by 108 interviews. All tasks were divided into direct and indirect patient care. Once the tasks were cataloged, then MDs and hospital managers graded the PA- or NP-performed tasks and assessed their contributions to the hospital management system.

**Findings:** In total, 2883 tasks were assessed. Overall, PAs and NPs performed a wide variety of clinical and administrative tasks, which differed across hospitals and medical specialties. Data from interviews and the hospital management systems revealed that over a third of the tasks were not properly registered or attributed to the PA or NP. After correction, it was found that the NP and PA spent more than two thirds of their working time on direct patient care.

**Conclusions:** NPs and PAs performed a wide variety of clinical tasks, and the consistency of these tasks differed per medical specialty. Despite the fact that a large part of the tasks was not visible due to incorrect administration, the interviews with MDs and managers revealed that the use of an NP or PA was considered to have an added value at the quality of care as well to the production for hospital-based medical care in The Netherlands.

## Background

A growing number of countries have expanded their medical services by incorporating the nurse practitioner (NP) or physician assistant (PA) (3)(12). For the most part, the reason is the increasing demand of healthcare due to a rising number of chronically ill patients, comorbidity, and an aging population (27)(30). Added to this social burden are growing costs of care, rising patient expectations, emerging technologies, and treatment opportunities. In turn, the demand of healthcare places pressure on governments and medical institutions to develop more effective and high-quality delivery systems (15). The incorporation of PAs and NPs on medical teams is evolving yet at the same time their inclusion seems to be a good fit. Both appear to be well suited to assume medical tasks that, at one time, were exclusively performed by physicians (13)(16)(36). Furthermore, the growing presence of PAs and NPs in North America and Europe suggests these are valued human resources readily available to accept the challenges of rising demand for medical services (4)(9)(21). However, to date, an inventory of tasks and responsibilities of NPs or PAs in hospital roles has only been recently documented (31). How they perform in direct patient care remains an area of interest to health workforce researchers and health care managers (9)(33). For the development of new professions, it is important that their contribution be visible (12), Allen 2015, (9). After all, descriptive and result-oriented work quantifications are necessary to communicate their worth to the patient care (3). Healthcare administrative systems can provide an important perspective about the tasks and responsibilities of their employees and are therefore more frequently used in health care research (23). This paper reports on tasks and responsibilities of Dutch PAs and NPs employed by hospitals. Since their introduction in The Netherlands, the number of PAs has grown from 347 in 2012 to 1231 in 2019 and the number of NPs increased from 1307 to 3672 in 2019 (5)(25)(32). As of 2019, there were 70 000 registered physicians (5). Since the introduction of the NP and PA, a series of studies have assessed the role, responsibility, and value to Dutch society (8). The Dutch Healthcare Authority in 2015 introduced a policy warranting that hospitals be reimbursed for the activities performed by a PA or an NP. This policy requires an accurate report of tasks and responsibilities of NPs and PAs. Nonetheless, it is unclear whether healthcare administrative systems are indeed accurate in showing tasks and responsibilities in medical care. Because their effect on medical services in hospitals has only been marginally described, we undertook an inventory of the tasks performed by NPs and PAs in four Dutch hospitals. Our aim was to:

- Describe tasks performed by PAs and NPs in hospitals,
- Categorize patient and non-patient-related tasks,
- Describe how the supervision and collaboration was organized and what the contributed value of the PA and NP was, and
- Assess the reliability of hospital administrative systems to capture the activity of PAs and NPs.

The intent of this study was to gain insight into the tasks that have been shifted from MDs to PAs and NPs. More importantly, how this task shifting is being valued and how visible the contribution is in the hospital-based management information systems.

### Theoretical framework

Based on the literature and discussions with health workforce researchers, the concept of medical tasks being shifted from doctor to PAs or NPs was cataloged into four categories: substitution of tasks, delegation of tasks, additional tasks, and other tasks (21). "Substitution of tasks" is defined as a structural transfer of assignments from physicians to any health professional (Table 1). The one assuming the task is responsible for the task. Which medical task a NP or PA performs is the result of consultation with the MDs (the doctor or the medical manager). In older literature, the term "delegation" was used to describe the transfer of physician-substituted roles and procedures and viewed as a labor economic term (28). "Delegation" in this sense was that the health professional performs the task under supervision; the physician gives specific directions how to perform the task and the physician remains responsible for the task (6)(28).

## Methods

### Study design

A combination of quantitative and qualitative research methods was used to gather information about the tasks shifted from a medical doctor to an NP or PA. This included financial administrative system data, roster information, outpatient appointment schedules, and a questionnaire with open and closed questions for NPs and PAs, along with semi-structured interviews involving MDs, managers, PAs, and NPs.

### Setting

Dutch hospitals that employed PAs and NPs were invited to participate in this research. Four hospitals met the following criteria:

1. Access to the financial system from which data could be extracted in such a manner that the activity was discernable per patient (diagnosis-treatment combination) and the provider could be identified;
2. There were no legal, moral, or technical obstacles that inhibited sharing the data with researchers.
3. Provide care to patients with both acute and chronic illnesses and have a variety of medical specialties.

Five hospitals were invited to participate (purposeful sample) and four enrolled in the study: three general hospitals and one university hospital.

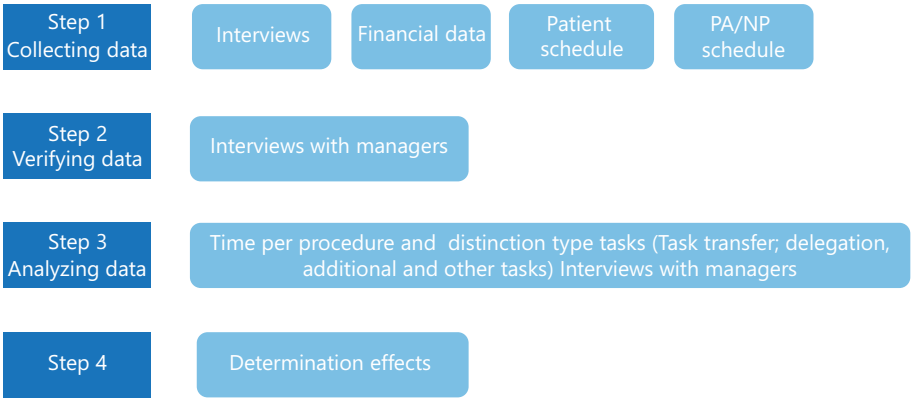
**Table 1.** Types of tasks undertaken by PAs and NPs in four Dutch hospitals

1. Substitution (transfer of tasks) is aimed at a structural transfer of tasks. This means tasks are carried out autonomously, the tasks are part of standard scheduling, and the NP or PA is considered to be fully responsible for the "transferred" task.
2. Delegation is the incidental transfer of tasks. It involves entrusting certain tasks to the NP or PA. In this respect, the temporary nature as well as the direct involvement of the physician (MD) is crucial, i.e., the task is not routinely planned and there is the possibility of direct supervision and intervention by the MD. The task is performed on behalf of the MD.
3. Additional tasks are an extension of the tasks of existing professionals. In this case, a distinction is made between "patient-related" and "non-patient-related" to point out the difference between, for example, psycho-social care and administrative/logistic tasks.

## Data collection and data analysis

We collected the information on all the tasks executed by an NP or PA, categorized the tasks, and analyzed the data. At the same time, we documented the time needed to perform the tasks and compared times with a physician normally executing the tasks, along with the time needed for physician supervision. Data collection and analysis followed a four-step approach (see Figure 1).

**Figure 1.** Data Collection and Analysis




### Step 1

Information was collected about the productivity of PAs and NPs from November 2015 to June 2016. Medical specialty data was obtained from the appointment schedules for outpatients and financial information from the hospital administrative systems. Concurrently, interviews with employed PAs and NPs were undertaken regarding their role, tasks, and productivity. Together with the questionnaires, the collected data resulted in a list of procedures and tasks involving patients treated by the NP or PA. Next, the recorded procedures and duration of the time with the patient were used to quantify the encounter. Any mismatch between the data from the administrative system and the outpatient schedule was reconciled by contacting the supervising medical specialist and/or financial data administrators at the hospital. In the catalog of procedures and tasks, we included "additional tasks." Additional tasks were those that were new as well as other tasks that could not be categorized from the hospital management system.

### Step 2

Trained researchers interviewed 35 clinic or department managers in the four hospitals. Collectively, the managers were responsible for the planning and control of daily activity and finances within the hospital or medical specialty departments. The interviews centered on the productivity of the hospital-based PA or NP. The managers and MD were asked to rate the overall contribution of the PA or NP in terms of quality of patient care and production on a visual analog scale from 1 to 10. Three researchers then independently analyzed the results, by following the algorithm from Figure

2 and reconciled any differences into one list. Next, we inventoried how many minutes the physician provided supervision for every procedure the NP or PA performed. Supervision was defined as instructing, collaborating, or overseeing the procedure. For validation purposes, the indicated time for executing a procedure with the patient was verified with the schedule of outpatient appointments; also assigned was the time the procedure started and when completed. In this way, we classified the degree of autonomy from the supervising medical doctor, triangulated with the patient's record (Figure 1). To distinguish the tasks, descriptive statistics were incorporated into:

- Type of task transfer,
- Number of tasks and activities,
- Duration of the execution of the task and needed supervision.

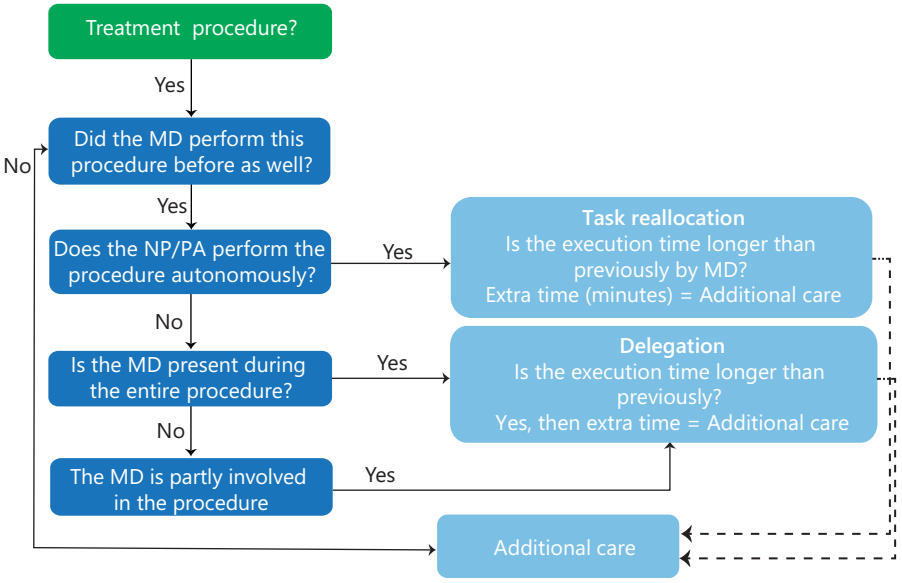
**Step 3**

The collected data were put into an Excel database. Included were detailed information about the tasks and the procedures performed by the PA or NP, along with any distinction between the recorded number of procedures in the outpatient schedule data and the performed procedures as reported by NP or PA. The data of the inventoried tasks were divided into three categories: substitution of tasks, delegated tasks, and additional tasks. These three categories were assigned a degree of independent performance based on what the PA or NP said and corroborated by the MD. The time to perform the task was stated in minutes using the electronic system (see Figure 2). All other activities not recorded in the hospital electronic information system, but mentioned in the interviews, were classified as overhead or "other tasks."

**Step 4**

The collaborating MD of each PA or NP assigned to the department was also asked broadly about the technical nature of the procedure. When inconsistencies emerged, additional information about the issue or task was reconciled by discussing the topic with the PA or NP, MD, and someone within the administrative system. In the interviews, we also asked what contribution the NP or PA added was in terms of quality of care and any contribution or value added to the production and efficiency of the service.

**Figure 2.** Task analysis flowchart identifies the data collection process.




## Results

The four included hospitals, from different regions in The Netherlands (south, east, west, and center of the country), differ from production, turnover, and number of staff. In this way, a representative selection has been made. We used the data from 75 NPs/PAs (that was 57% of the total population of PAs and NPs employed by the four hospitals at the time of the study). We interviewed 38 MDs and 20 managers. Also of the 75 NPs/PAs, we selected 32 NPs and 21 PAs for interviews, per participating department only 1 NP and 1 PA. Based on a comparison of the characteristics of the interviewees such as average age, experience as NP or PA, and the total work experience in healthcare with the characteristics of a national inventory among alumni (25)(32), we included a representative sample of NPs and PAs. The mean working hours per year for these NPs and PAs were, respectively, 1381 (SD 238) and 1502 h (SD 272) (Table 2). In total, 2883 h of the included PA/NP time was assessed over 8 months. The number of hours spent on tasks was parsed into the four task categories. Task substitution was 22–31%, task delegation was 2–4%, and "additional tasks" was 9–18%. According to the four hospital-based administrative systems that documented their activity, NPs and PAs spent more than half their time on "other tasks" (55–58%).

**Table 2.** Number of hours spent on tasks (based on 8 months). Financial administration records combined from all four institutions.

| | NP (N=32) | | PA (N=21) | |
|---|---|---|---|---|
| | Hours | % | Hours | % |
| Task substitution | 309 | 22% | 465 | 31% |
| Task delegation | 52 | 4% | 34 | 2% |
| Additional tasks | 254 | 18% | 128 | 9% |
| Other tasks | 766 | 55% | 875 | 58% |
| **Total:** | **1,381** | **100%** | **1,502** | **100%** |

### Task transfer

When the tasks were delineated into departments or medical specialties, there were wide variations in the categorization of tasks among the different medical specialties where the PA or NP was active (Figure 3). The greatest task substitution was in geriatrics (58%) and the least in hematology (13%). Across specialties, the maximum part of the activities of an NP/PA was classified in the broad category of "other tasks." When profiles derived from hospital administrative systems were adjusted with the outpatient schedule and the data from the interviews correlated, what emerged was that "other tasks" were mainly those involving an aspect of direct patient care such as prescribing or arranging some patient accommodation. These tasks were moved into the category of "task substitution" because these activities were undertaken by physicians prior to the incorporation of PA or NP (Table 3). When patient-based (i.e., substitution, delegation, and additional tasks) and non-patient-based tasks were further parsed, on average, 46% of "other tasks" were related to direct patient care (Table 4). However, these were tasks not visible from the administrative record of physician activity. When these tasks were re-categorized to task substitution, an NP spent, in total, 73% on patient-based care and a PA 71%.

**Table 3.** Hours spent on tasks (based on 8-months) after re-categorization of other tasks to task substitution based on interviews.

| | NP (N=32) | | PA (N=21) | |
|---|---|---|---|---|
| | **Hours** | **%** | **Hours** | **%** |
| Task substitution | 708 | 51% | 906 | 60% |
| Task delegation | 52 | 4% | 34 | 2% |
| Additional tasks | 253 | 18% | 129 | 9% |
| Other tasks | 368 | 27% | 433 | 29% |
| **Total** | **1,381** | **100%** | **1,502** | **100%** |

The additional "other tasks" or administration tasks mentioned in the interviews were further delineated into:

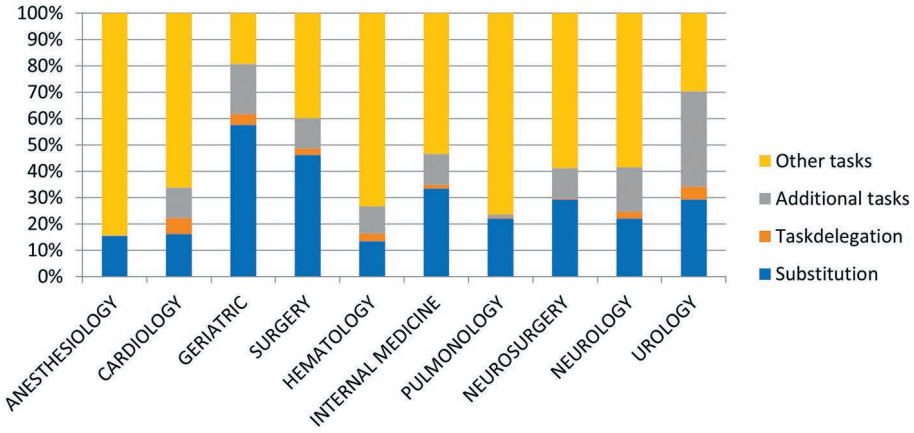
- Requests for laboratory tests,
- Arranging appointments,
- Consultation (not about individual patients), planning, discharge, etc.

"Other tasks" also included clinical research, education/ professional development, organizational tasks, education/teaching, and intercollegiate consultation (Table 4).

**Table 4.** Other Tasks

| | **NP** | **PA** |
|---|---|---|
| | **Hours** | **Hours** |
| Administrative | 61 | 91 |
| Research | 44 | 48 |
| Expertise enhancement | 40 | 38 |
| Organizational tasks | 36 | 38 |
| Education (teaching) | 40 | 34 |
| Consultation between medical specialist and PA/NP | 24 | 48 |
| Remainder of the group | 89 | 111 |
| **Total Hours** | **368** | **433** |

**Figure 3.** Differences between medical specialty departments




### Supervision and collaboration

The analysis of tasks also revealed that the presence of the physician overseeing the PA or NP was only reported a third of the time. For the NP, it was 64% of the cases and for the PA in 68% of the cases that they executed the task or procedure autonomously (without supervision or consultation). If there was a consultation with the MD, the average time was 6 min (SD 1.91). In regard to consultant availability, 36% of the NPs, 64% of the PAs, and 40% of the MDs concluded that "consultation between a PA or NP with the MD should always be made available" when requested.

The interviews revealed that an NP or PA, on average, was scheduled for a longer period of time for a patient consult than the physician: an NP 15 min (SD 2.53) longer and a PA 7.5 min (SD 2.57) longer. The PAs and NPs claimed that they provided the patient more information because the patients asked more questions than when the MD was the proceduralist.

The time spent on providing additional information to patients was categorized as "additional tasks." Some NP/PAs respond in the interviews that they needed more time per consult because they had no assistance from a medical assistant.

At the same time the managers and MDs offered that the deployment of the NP or PA enhanced the quality of patient care and improved the production and efficiency of the medical service.

## Discussion

This description, assessment, and quantification of tasks of hospital-based PAs and NPs was based on documented procedures and interviews about the procedures.

Of those procedures assessed in this 8-month time frame, NPs performed 26% of all the medical tasks recorded in a systematic way, and PAs 33% (task substitution and delegation together, see Table 2). The interviews and validation process (triangulation as described in step 4 of the data analysis) revealed that there was a relatively low registration or documentation of clinical tasks prior to completion of this study. This omission was largely attributed to hospital policies or procedures that were inconsistent and not standardized in how they were recorded. In fact, once the data was reconciled, the PA performed 62% and the NP 55% of their working time on clinical tasks that previously had been performed exclusively by physicians (i.e., task substitution and delegation combined, see Table 3).

Another finding was the division of labor between PAs and NPs. In this study, the results show some minor differences between the PAs and NPs. The PA appeared to be performing clinical tasks more independently than NPs; however, these differences were not statistically analyzed, but their similarity and interchangeability has been noted by other observers (14).

Furthermore, the medical and administrative staff regarded both professions equally and did not see much difference. This was because, in part, both spent a large part of their working time on direct patient care. Time-motion studies are needed to better quantify how PAs and NPs function in hospital settings (2)(26). What PAs and NPs do, how well they do it, and what impact this has on patient-centered results are a needed piece of health service research (11)(19)(20)(24)(31). One finding in this study revealed that a great number of tasks performed by a PA and NP in Dutch hospitals were not visible to administrators due to lack of documentation or registration. The reasons were:

- The administrative systems in the hospitals were not consistently prepared for PAs or NPs that performed independently tasks or procedures.
- PAs and NPs were not always able or willing to fill in the information into the hospital informatics system.
- Sometimes a medical specialty had a policy that did not permit a PA or an NP to document the tasks or procedures.

- PAs and NPs performed a great deal of overhead tasks that do not exist or did not have a category in the administrative system.

These tasks can be described as patient-centered clinical management. Such tasks appear to contribute to the continuity of care (facilitating patient flow, an easier access for nurses to the medical team, and more information for the patient and their next of kin). The additional set of medical providers seem to connect healthcare professionals around patients and their families and are perceived by the staff as a safety net for everything that needs to be aligned and coordinated. These findings are quite similar to the findings of Drennan et al. who researched the role of physician associates in secondary care in the United Kingdom (9). To paraphrase, the NPs and PAs improve hospital functioning with their low visibility of tasks, but are missed when absent (12), (Allen 2015). The outcome of care by a PA or NP, in terms of quality of care, as well as any contribution or value added to the production and efficiency of the care, is regarded at the same level as a MD based on a large number of observations that tend to transcend time, country, and type of patient (2)(9)(16)(22)(26)(31). The shifting of clinical tasks from physicians to PAs or NPs was one of the main goals for the introduction of these professions and remains an important component of their visibility and development (10)(28)(29). Where there is low visibility of the NP and PA contribution to the medical care, there cannot be an objective recognition (26). Without recognition, there is the danger that the development of a relatively young profession will be undermined (12).

**Methodological considerations**

The strength of this study lies in its novel method of understanding the concept of shifting clinical tasks in hospital settings. The use of an administrative approach to obtain a broad overview of task activity was needed as a first foray into this unknown area of medical labor research. Administrative data is a starting point for investigation of role activity because it can serve as a contrast to self-reported data in surveys and interviews – which is retrospective and assumed to be vulnerable for recollection bias. However, this assumption has not been well tested – especially as it applies to PAs and NPs. A flexibility of methods has been promoted in administrative research by Lazarfeld (1993) and continues today when public and government are involved in funding policy initiatives (7). One aim is to not only interview different professionals and managers but also gather objective data from outpatient schedules and the financial registration needed for correlation and validation purposes. The files of

these different hospital sources were integrated with data analyses and crosschecked during data collection. Discrepancies in the financial system capture of reimbursable procedures, outpatient schedules, and interviews were discussed with the managers and supervising medical specialists along the way. By using the results of the interviews and the data from the administrative system along with representative patient planning activities, the research team was able to objectify that the PA or NP may have been acting as contributors to a more efficient hospital service delivery. Through this triangulation and analyzing data as a whole, we reduced the chance of information and recall bias.

There are a number of limitations of this study. First is that the research was confined to four hospitals. Furthermore, the contributions of the PAs and NPs were measured by interviewing the professionals but at the same time revealing that the registration of tasks in the financial system was not always properly documented. Patient satisfaction was only researched indirectly as the study did not include patient impressions. However, we believe the stage is set with this study for a broader investigation that would include acceptance and satisfaction of patients by an array of providers undertaking various tasks.

## Conclusion

The World Health Organization (WHO) has identified "task shifting" or "task transfer" as the rational redistribution of tasks among health workforce teams (34). Globally, the introduction of PAs and NPs, in terms of positioning and contribution, has resulted in a wide variety of roles including hospital employment. Our research revealed that PAs and NPs based in hospitals were taking on more clinical tasks than could be derived from the management system alone because the documentation of these tasks was inadequate or ineffective. At the same time, managers and MDs reported appreciating the contribution of their skills, availability to offset tasks, and providing a team-based approach to healthcare. Especially, the tasks that help the patient flow are very important but were not visible. The contribution of NPs and PAs in the direct patient care has become more visible which in turn leads to more reliable assessment of the activities as an important condition for the communication about their worth to the hospital and a further implementation of these professions in the Dutch healthcare system.

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# 4

# The involvement of physician assistants in inpatient care in hospitals in the Netherlands: a cost-effectiveness analysis

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## Abstract

**Objective:** To investigate the cost-effectiveness of substitution of inpatient care from medical doctors (MDs) to physician assistants (PAs).

**Design:** Cost-effectiveness analysis embedded within a multicenter matched-controlled study. The traditional model in which only MDs are employed for inpatient care (MD model) was compared with a mixed model in which besides MDs also PAs are employed (PA/MD model).

**Setting:** 34 hospital wards across the Netherlands.

**Participants:** 2292 patients were followed from admission till 1 month after discharge. Patients receiving daycare, terminally ill patients and children were excluded.

Primary and secondary outcome measures: All direct healthcare costs from day of admission until one month after discharge. Health outcome concerned quality-adjusted life years.

**Results:** We found no significant difference for QALY gain (+0.02, 95% CI -0.01–0.05) when comparing the PA/MD model with the MD model. Total costs per patient did not significantly differ between the groups (+ € 568, 95% CI €-254–€1391, p=0.175). Regarding the costs per item, a difference of 309 euro per patient (95% CI €29–€588, p=0.030) was found in favor of the MD model regarding length of stay. Personnel costs per patient for the provider who is primarily responsible for medical care at the ward, was lower on the wards in the PA/MD model (€-11, 95% CI €-16–€-6, p=0.000).

**Conclusions:** This study suggests that the cost-effectiveness on wards managed by PAs is similar to the care on wards with traditional house staffing. The implementation of PAs may reduce personnel costs, but not overall healthcare costs.

## Background

Because of an increased appreciation of continuity of care, pressure to deliver healthcare efficiently, and local shortages of medical doctors (MDs), medical care for admitted patients is increasingly reallocated to physician assistants (PAs)(1-3). A PA is a health professional licensed to practice medicine in defined domains, with variable degrees of professional autonomy (4). PAs who provide medical care for admitted patients usually work in a team comprising both PAs and MDs (i.e. residents or medical specialists).

Literature suggests that PAs add to the quality of care by increasing continuity for both patients and hospital staff (1). The turnover of house staff is traditionally high due to use of recent medical graduates who are planning to do fellowships and the mandatory rotational cycles. PAs generally do not rotate and constitute a factor of stability in the continually changing medical workforce. Previous studies show that quality of care for admitted patients delivered by a PA-based team is comparable to that of a resident-based team, and that patient evaluations are at least as good (5-10). Our own study showed similar quality and safety of care, but better patients experiences on wards with a PA-based team (11). Estimates of PA employment on costs vary across the conducted studies (5)(6)(10). These studies concerned one clinical discipline within one hospital, which reduces the generalizability of findings. Given the outcomes of these studies and their limitations, we conducted a multicenter study that included PAs providing care to hospitalized patients including a range of clinical disciplines. This paper reports on the cost-effectiveness of substitution of inpatient care from MDs to PAs.

## Methods

### Study design

This economic evaluation was performed alongside a multicenter non-randomized matched-controlled study, which was performed in the Netherlands. In this study, the care on wards utilizing a mixed 'PA/MD model' (intervention group) was compared with the care on wards utilizing a solely 'MD model' (control group).

### MD model

In the MD model, only MDs are in charge of the admitted patients at a specific hospital department. Most of them are residents. The resident is

physically present at the department each weekday and is the first point of access to medical care during office hours (MR model). Their work includes daily clinical care and patient management. The residents are supervised by medical specialists. In some cases, especially 76 in smaller hospitals where often no residents are employed, the medical specialists provide all medical care for the admitted patients (MS model).

**PA/MD model**

In this model, the PAs who were employed at the wards are substitutes for the residents. Their tasks and responsibilities are largely comparable. PAs have the same authorizations as residents: they can make indications for treatment, perform predefined medical procedures and subscribe medication independently within their field of expertise (12). We included two different models within the intervention group: a model in which PAs collaborate with residents (mixed PA/MR model) and a model in which only PAs are the first point of access to medical care (PA model). In both models, the PAs as well as the residents were supervised by medical specialists.

Control wards were matched with the intervention wards on the basis of medical specialty and hospital type. Hospital wards were included in the intervention group if the PA covered at least 51% of the available ward care hours per week during dayshifts on weekdays. Wards were included in the control group if exclusively MDs provided medical care. The primary analysis had patients' length of stay as primary outcome. Further details of the study design have been described elsewhere (13). The economic analysis was conducted from a healthcare perspective, with a time frame from admission till one month after discharge.

**Study population**

This study focused on the patients admitted to the hospital wards. Exclusion criteria for patients were:

1. Younger than 18 years;
2. Terminally ill;
3. Receiving daycare.

Daycare was defined as hospital admissions that were intended to last 24 hours or less.

**Health outcome**

The primary health outcome in this evaluation is the QALY (quality-adjusted life years). A QALY is a generic measure of disease burden (14). QALYs were derived using the EuroQoL-5D questionnaire (EQ-5D-3L)

(15), which is a widely used validated patient questionnaire comprising five domains: mobility, self-care, usual activities, pain, and anxiety/depression. Each domain has three possible levels indicating; no problems, moderate problems or severe problems. The EQ-5D-3L was assessed at three time points: at admission, discharge and one month after discharge. We used the Dutch utility weight to calculate utilities (16).

**Cost outcomes**

The primary cost outcome was the sum of direct costs associated with the principal admission and costs that occurred within one month after discharge that were potentially related to hospital admission. Resources used during admission were extracted in detail at an individual patient level from patient medical records and included laboratory tests, diagnostic tests, medication and blood products. Also the frequency and type of consultations of healthcare suppliers and the number of days of unplanned stay at an intensive care unit were derived from the medical records. To minimize information bias, a random sample of 10% of the patient records per ward was reassessed by a second researcher, who was blinded for the results from the initial researcher. In case of an inter-rater agreement of less than 95%, the records of the total sample were reassessed.

Personnel costs included the costs for the residents, PAs and medical specialist who were primarily employed for medical care for the admitted patients. Also the costs for supervision time were included. We measured the number of hours spend for medical ward care per professional by examination of work schedules. All MDs and PAs who had the primary task to provide medical care for admitted patients were asked to fill in their real work schedule during four fixed weeks: week 3, 7, 11 and 15 after the start of the inclusion of patients. Next, we divided the number of working hours by the number of patients for which they were in charge. The number of hours spent for supervision was derived from an online questionnaire. We asked each attending physician for the average number of hours they weekly spend for supervision. These hours were added up for all attending physicians of the department, and divided by the number of patients who were admitted at the ward. Volumes which were measured between discharge and one month afterwards included days of unplanned readmission, number of presentations at emergency departments, number of contacts with a general practitioner, and the required home care. These volumes were collected from a patient questionnaire that was sent one month after discharge. Costs were calculated by multiplying the volumes of healthcare use with corresponding unit prices, derived from the Dutch

Manual for Costing Research (17). All figures were related to the price level of the same year (i.e. 2014). Details of the costs applied to units of resource use are provided in supplemental Table.

**Sample size calculation**

Sample size calculation was based on length of stay (LOS), which was the primary clinical outcome of the multicenter study. Results for LOS have been published elsewhere (11). The originally published sample size calculation (13) was adjusted prior to start of data collection (18). To detect a relative difference in LOS of 20% between the 'PA/ MD model' and 'MD model', assuming an average LOS of 6 days (SD 4.9), alpha 5%, power 80% and an Intra Cluster Coefficient of 0.06 for patients in same ward, 30 wards including 100 patients each were required. Taking into account an expected drop-out of maximum 2 matched pairs, 34 wards (17 in each arm) with each 100 patients were required. In case of no drop-out, 50 patients per ward would be sufficient.

**Data analysis**

We used descriptive analyses with counts (and proportions) or means (with SDs) to describe baseline characteristics, effects, and costs. The a priori planned analysis was a comparison between the intervention and control group on incremental costs and incremental effects. The incremental effects were analyzed using a linear mixed model approach with the QALY score as dependent variable and group and baseline QALY as independent variables, taking clustering of patients within wards into account. If similar effects on the QALY in both groups were found, a cost-minimization approach was performed by comparing differences in costs between groups using a linear mixed model approach accounting for clustering and applying bootstrapping (200 times) to create bias-corrected 95% CIs around the coefficients of the independent variables. A total of 50–200 replications are generally adequate for estimates of standard error (19).

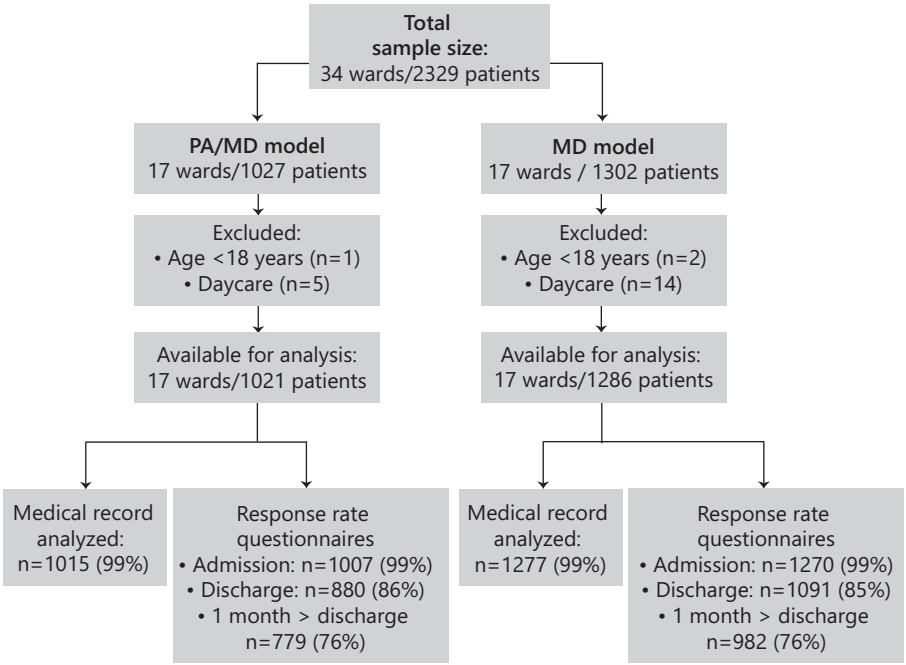
Multivariable models were constructed to adjust for potential confounders. We took matching into account by adding covariables for the matching variables. Missing data were imputed via multiple imputations. To explore uncertainty around costing assumptions (i.e. cost-prices and salary), sensitivity analysis was conducted on the range of extremes. Imputation models for all cost categories and utility scores were then redone accounting for changes in the sensitivity analysis. To explore heterogeneity within the results, post-hoc subgroup analyses were performed for each submodel of medical ward care: the MS model, MR model, mixed PA/MR model and the

PA model. All analyses were carried out with Stata 11.2 (StataCorp, College Station, TX). P-value was set at 0.05 to indicate statistical significance.

## Ethical considerations

Ethical approval was received from the Research Ethics Committee of the Radboud university medical center, Nijmegen (registration number: 2012/306); the committee judged that ethical approval was not required under Dutch Law. All data were handled strictly confidential and written informed consent was obtained from all patients.

**Figure 1.** Flow-chart of patients




## Results

We included 1,021 patients spread over 17 hospital wards in the intervention group, and 1,286 patients spread over 17 hospital wards in the control group (Figure 1). The main patient characteristics are summarized in Table 2. Most characteristics were well balanced between the two groups.

More patients in the intervention group were acutely admitted (59% versus 44% in the control group, p<.001). Also the primary diagnosis differed significantly.

**Length of stay**

We had complete data about LOS of 99% of the patients (Figure 1). Results for the crude and adjusted associations between the organizational models and LOS are shown in table 3. Median LOS of the patients in the intervention group was 6 days (IQR 4–10), median LOS of the patients in the control group was 5 days (IQR 4–8). The involvement of PAs was not significantly associated with the crude LOS (ß 1.22, 95% CI 0.99–1.51, p=.062). The beta of the final model did not change substantially after adjustment for potential confounders and remained non-significant (ß 1.20, 95% CI 0.99–1.40, p=.064).

**Quality and safety of care**

We were able to check 99% of all patient records. Item-missing varied from 1% (in-hospital mortality) to 24% (discharge letter). Incidence of unplanned readmission and presentation at the emergency department were derived from the patient questionnaire, which was sent one month after discharge. The response rate on this questionnaire was 76% in both study arms (Figure 1). The indicator 'incidence of episode of at least two days pain score ≥7' showed a significant association with the inpatient care model (OR 1.60, 95% CI 1.09–2.35) when not adjusted for confounding. After adjustment for confounders, none of the indicators for quality and safety of inpatient care were related to the involvement of PAs (Table 3).

**Patient experiences**

The response rate on the questionnaire at discharge was 86% in the intervention group and 85% in the control group (Figure 1). The item non-response rate varied from 15% to 27%, including the questions answered with 'not applicable'. The overall evaluation of medical care by patients was on average 8.4±1.3 in the intervention group and 8.0±1.5 in the control group. The involvement of PAs was significantly associated with more positive overall evaluations of care by patients (β 0.49, 95% CI 0.22–0.76, p=.001). Experiences of patients with all separate domains communication, continuity, cooperation and medical care were also significantly better on the wards that involved PAs (Table 4).

**Table 1.** Baseline characteristics of patients

| Baseline characteristic | PA/MD model (n=1021) | MD model (n=1286) | P Value |
|---|---|---|---|
| Medical specialty n(%) | | | <.001 |
| Surgery | 601 (59%) | 696 (54%) | |
| Gastroenterology | 102 (10%) | 181 (14%) | |
| Pulmonology | 91 (9%) | 107 (8%) | |
| Cardiology | 101 (10%) | 124 (10%) | |
| Orthopaedics | 103 (10%) | 100 (8%) | |
| ENT, head and neck oncology surgery | 23 (2%) | 78 (6%) | |
| Hospital type n(%) | | | <.001 |
| Teaching | 552 (55%) | 709 (53%) | |
| Academic | 23 (2%) | 78 (3%) | |
| Non-academic | 529 (52%) | 631 (50%) | |
| Non-teaching | 469( 56%) | 577 (57%) | |
| Gender, male n(%) | 524 (53%) | 682 (54%) | .47 |
| Age, years mean ± SD | 64 ± 16 | 63 ± 15 | .11 |
| Major diagnoses n(%) | | | <.001 |
| Digestive system | 204 (20%) | 247 (19%) | |
| Circulatory system | 158 (16%) | 274 (22%) | |
| Neoplasms | 108 (11%) | 195 (15%) | |
| Musculoskeletal system and connective tissue | 120 (12%) | 119 (9%) | |
| Injury and poisoning | 135 (13%) | 80 (6%) | |
| Infectious and parasitic diseases | 59 (6%) | 81 (6%) | |
| Respiratory system | 51 (5%) | 75 (6%) | |
| Charlson index for co-morbidity score mean ± SD (% with score ≥1) | 1.1±1.8 (43%) | 1.1±1.8 (44%) | .65<br>.66 |
| Highest education n(%) | | | .15 |
| Low | 371 (38%) | 422 (34%) | |
| Middle | 380 (39%) | 489 (40%) | |
| High | 233 (24%) | 328 (27%) | |
| Ethnicity, Dutch n(%) | 976(99%) | 1212 (98%) | .15 |
| Marital status n(%) | | | .29 |
| No partner | 136 (14%) | 167 (14%) | |

| Baseline characteristic | PA/MD model (n=1021) | MD model (n=1286) | P Value |
|---|---|---|---|
| Partner | 730 (74%) | 949 (77%) | |
| Widow | 119 (12%) | 125 (10%) | |
| Smoking status n(%) | | | .65 |
| No, never smoked | 325 (33%) | 385 (31%) | |
| No, but ever smoked | 494 (48%) | 626 (50%) | |
| Yes, still smoking | 174 (17%) | 230 (19%) | |
| Body Mass Index (mean ± SD) | 27±5 | 27±5 | .79 |
| Number of hospitalizations for same problem n(%) | | | .20 |
| 1 hospitalization | 580 (59%) | 693 (56%) | |
| >1 hospitalization | 403 (41%) | 540 (44%) | |
| Type of admission n(%) | | | <.001 |
| Elective | 402 (41%) | 687 (56%) | |
| Urgent | 588 (59%) | 547 (44%) | |
| Discharge destination n(%) | | | <.001 |
| Home | 765 (90%) | 965 (92%) | |
| Hospital | 12 (1%) | 30 (3%) | |
| Nursing home/rehabilitation center/hospice | 56 (7%) | 28 (3%) | |
| Family relative | 18 (2%) | 25 (2%) | |
| Health related quality of life at admission | 63±19 | 64±20 | .08 |
| Workload at the ward: minutes per bed per week (mean ± SD) | 111±48 | 130±72 | <.001 |

Note: Numbers may not add up to the total because of missing values

### Subgroup analyses

Results for the analyses per submodel of medical ward care are shown in supplemental Table S1. No differences were found between the groups for LOS. Regarding the indicators for quality and safety, we found significant differences for the incidence of hospital infections, pressure ulcer, episode of two days body temperature ≥38, and episodes of two days Numeric Rating Score ≥7. The scores on these indicators were lowest for the MS model. Patient evaluations were significantly highest for the PA model and the mixed PA/MR model.

**Table 2.** Utilities at admission, discharge and 1 month after discharge, and QALY gained

| Outcome | PA/MD model (n=1015) mean (SD)* | MD model (n=1277) mean (SD)* | Difference mean (95% CI) | P Value |
|---|---|---|---|---|
| EQ-5D | | | | |
| Baseline (admission) | 0.64 (0.28) | 0.68 (0.29) | −0.04 (−0.12 to 0.03) | 0.247 |
| Discharge | 0.71 (0.22) | 0.72 (0.23) | −0.01 (−0.06 to 0.04) | 0.634 |
| One month after discharge | 0.75 (0.23) | 0.78 (0.22) | −0.04 (−0.09 to 0.02) | 0.178 |
| QALY gain during admission | 0.07 (0.25) | 0.04 (0.25) | 0.03 (−0.02 to 0.08) | 0.213 |
| QALY gain after discharge† | 0.04 (0.22) | 0.05 (0.21) | −0.02 (−0.07 to 0.02) | 0.216 |

* Values are summary estimates obtained by multiple imputation.

† Difference in QALY between 1 month after discharge and discharge, adjusted for baseline utility.

EQ-5D, EuroQol five dimensions questionnaire; MD, medical doctor; PA, physician assistant; QALY, quality-adjusted life years.

**Table 3.** Total costs per patient and costs per item (€)

| Item | PA/MD model (n=1015) Mean (SD)* | MD model (n=1277) Mean (SD)* | Difference† Mean (95% CI) | P Value |
|---|---|---|---|---|
| Costs associated with principal admission | | | | |
| Length of stay | 1780 (1811) | 1421 (1210) | 309 (29 to 588) | 0.030 |
| Non-elective transfer to ICU | 333 (3267) | 182 (1761) | 105 (−262 to 473) | 0.575 |
| Resources used during admission | | | | |
| Medication | 344 (848) | 243 (748) | 99 (−9 to −207) | 0.073 |
| Laboratory tests | 107 (168) | 99 (136) | 19 (−16 to 44) | 0.366 |
| Diagnostic tests | 163 (229) | 154 (235) | −1 (−44 to 42) | 0.970 |
| Blood products | 31 (122) | 36 (117) | −12 (−37 to 14) | 0.371 |
| Consultation with healthcare suppliers | | | | |
| Medical or surgical consultant | 30 (93) | 19 (47) | 4 (−6 to 13) | 0.437 |
| Paramedics and specialist nurses | 96 (159) | 73 (121) | 14 (−20 to 48) | 0.429 |
| Personnel | | | | |
| PA/MD who is primarily responsible for medical care | 71 (29) | 103 (44) | −31 (−33 to −28) | <0.01 |
| Supervision by staff physician | 156 (93) | 129 (104) | 43 (39 to 47) | <0.01 |
| Exclusion of wards with staff physicians only | 156 (93) | 173 (77) | −11 (−16 to −6) | <0.01 |
| Costs occurred during first month after discharge | | | | |
| Presentation at emergency department | 108 (182) | 114 (298) | −13 (−45 to 20) | 0.448 |
| Non-elective readmission | 456 (1333) | 421 (1142) | 1 (−89 to 92) | 0.977 |
| Contact with general practitioner | 55 (73) | 53 (70) | 0 (−7 to 7) | 0.923 |
| Required home care | 121 (248) | 98 (214) | 11 (−9 to 30) | 0.275 |
| Total costs | 3480 (5196) | 2869 (3260) | 568 (−254 to 1391) | 0.175 |

*Values are summary estimates obtained by multiple imputation.

†Difference in mean costs per patient in the PA/MD group minus the MD group with bootstrapped 95% CI, adjusted for medical specialty, hospital type, diagnosis, comorbidities, type of admission and discharge destination.

ICU, intensive care unit; MD, medical doctor; PA, physician assistant.

Results for the analyses for surgical specialties only are described in supplemental Table S2. The patients on the wards with a PA/MD model had a significantly higher incidence of pressure ulcer (OR 0.42, 95% CI 0.21–0.88) and episode of at least two days pain score ≥ 7 (OR 0.21, 95% CI 0.15–0.67), but a significantly lower number of presentations at the department of emergency after discharge (OR 1.47, 95% CI 1.02–2.13). Evaluations of patients were significantly better on wards with the PA/MD model.

In supplemental Table S3 the results for the non-surgical wards are summarized. We found significant differences in the incidence of presentation at the department of emergency and unplanned readmission in favor of the control group. The number of days between discharge and discharge letter differed significantly in favor of the intervention group: β -0.22, 95% -1.00–0.57.

**Table 4.** Costs (€) per patient per submodel of medical ward care

| Item | PA/MD model (n=1015) | | MD model (n=1277) | | P Value |
|---|---|---|---|---|---|
| | PA/MR model (n=698) Mean (SD)* | PA model (n=317) Mean (SD)* | MR model (n=924) Mean (SD)* | MS model (n=353) Mean (SD)* | 1=PA/MR model 2=PA model 3=MR model 4=MS model |
| Costs associated with principal admission | | | | | |
| Length of stay at the ward | 1921 (1949) | 1469 (1413) | 1557 (1335) | 1064 (675) | 1 vs 4: p=0.045 |
| Non-elective transfer to ICU | 468 (3935) | 45 (494) | 249 (2072) | 17 (322) | NS |
| Resources used during admission | | | | | |
| Medication | 365 (943) | 297 (600) | 280 (869) | 130 (194) | NS |
| Laboratory tests | 116 (167) | 85 (170) | 114 (149) | 58 (78) | NS |
| Diagnostic tests | 202 (253) | 73 (121) | 152 (249) | 155 (195) | NS |
| Blood products | 16 (89) | 61 (171) | 33 (130) | 42 (71) | 1 vs 2: p<0.01<br>3 vs 2: p<0.01 |
| Consultation with healthcare suppliers | | | | | |
| Medical or surgical consultant | 35 (108) | 18 (41) | 21 (50) | 11 (30) | NS |
| Paramedics and specialised nurses | 97 (175) | 94 (120) | 72 (130) | 73 (90) | NS |
| Personnel | | | | | |
| PA/MD who is primarily responsible for medical care | 80 (31) | 51 (3) | 93 (42) | 129 (37) | 1 vs 4: p<0.01<br>2 vs 4: p<0.01<br>3 vs 4: p<0.01<br>1 vs 3: p<0.01<br>2 vs 3: p<0.01<br>2 vs 1: p<0.01 |

| Item | PA/MD model (n=1015) | | MD model (n=1277) | | P Value |
|---|---|---|---|---|---|
| | PA/MR model (n=698) Mean (SD)* | PA model (n=317) Mean (SD)* | MR model (n=924) Mean (SD)* | MS model (n=353) Mean (SD)* | 1=PA/MR model 2=PA model 3=MR model 4=MS model |
| Supervision by staff physician | 173 (100) | 121 (59) | 178 (79) | NA | 1 vs 3: p=0.019<br>2 vs 3: p<0.01<br>2 vs 1: p<0.01 |
| Costs occurred during first month after discharge | | | | | |
| Presentation at emergency department | 112 (182) | 101 (182) | 125 (296) | 88 (307) | NS |
| Non-elective readmission | 455 (1176) | 467 (1647) | 438 (1054) | 388 (13 564) | NS |
| Contact with general practitioner | 57 (75) | 53 (69) | 54 (72) | 51 (67) | NS |
| Required home care | 109 (222) | 150 (298) | 104 (229) | 86 (174) | 2 vs 1: p=0.029<br>2 vs 3: p=0.031<br>2 vs 4: p=0.025 |
| **Total costs** | **3807 (5997)** | **2754 (2536)** | **3154 (3625)** | **2120 (1809)** | **NS** |

## Discussion

In the present study, we aimed to determine the effects of substitution of inpatient care from MDs to PAs on patients' LOS, quality and safety of care, and patient experiences with care provided. No difference between the two study arms was found on these measures, except that the involvement of PAs was significantly associated with better patient experiences. In particular, patients rated communication, continuity, cooperation and medical care better on wards with PAs. Our findings do not confirm our hypothesis that patients' LOS would be shorter on wards on which PAs are involved in inpatient care. Reducing LOS is an aim for policy makers in many healthcare systems (21). As a consequence, in the Netherlands as well as in many other countries, reducing LOS has been of major interest in the previous decade (22). Due to several interventions, the average LOS decreased from 11.2 days in 1990 to 9.0 days in 2000 and 6.4 days in 2012 (23). Although there are still variations in LOS between countries and hospitals, it is debatably what decrease of LOS is feasible. To our knowledge, this is the first multicenter study that investigates the effects of reallocating inpatient care from MDs to PAs. A few single-centered studies have compared non-acute inpatient care delivered by a PA-based team with the care delivered by a resident-based team (9-13). All studies reported similar quality of care for PA and non-PA care, which is in line with our results. However, the results regarding LOS were mixed. Singh et al. (10) reported that the PA-based team was associated with an increased patients' LOS, while Nishimura et al. (12) and Miller et al. (13) reported an association with a decreased LOS. Comparable to our results, Roy et al. (9) and Dupher et al. (11) showed similar LOS between de study arms. These studies can however hardly be compared, because different methodology was used, and different patient groups were involved. Besides, most of these studies compared a hospitalist/PA model with the traditional resident-based model, while hospitalists were not part of the models we involved (16). Hospitalists have been introduced in the Netherlands since 2012 and were not graduated yet at the start of our study. The PAs in our intervention model were supervised by staff physicians of the specific clinical discipline, instead of the hospitalists who have a supervising role in the PA/hospitalist models in the USA. Based on the descriptions, the tasks of the PAs who are employed for inpatient care in the Netherlands, appear to be largely comparable to the tasks of the PAs in the USA, which makes it unlikely that differences in team composition would affect the results.

Contrary to some of above-mentioned studies which showed no differences between PAs and MDs on patient experiences (9)(11)(12), we

found significantly better patient experiences on wards with PAs. This difference in findings might be the result of a specific focus on experiences in medical inpatient care, whereas the other studies focused on the general care-giving team with often low response rates. Nonetheless, one could debate about the relevance of the statistically significant differences on patient experiences, since the scores in both groups indicate (very) positive experiences. Although the study was not designed to confirm equivalence between study arms, our study suggests that the care on wards with the PA/MD model is not different from the care on the wards with traditional house staffing. Employing a PA for inpatient care seems to be safe. PAs may be a cost-effective alternative for residents and hospitalists, because they can be trained faster, and the cost of their training is significantly lower compared to MDs. As shown in Table 2, the time spend on inpatient care (i.e. workload at the ward) is less in the PA/MD group than in the MD group. This indicates advantages on healthcare costs as well. The less time might be related to our previous finding that the provider continuity is more constant on wards with PAs, and that PAs are more experienced than residents (16). As a consequence, PAs might be more familiar with the clinical protocols and the procedures to for example request diagnostics tests and consultation of other (sub)specialties. Therefore, they spend less time on such indirect patient care. Furthermore, as a consequence of the higher provider continuity, PAs might be more familiar with the routines of other individual professionals, the medical team on the ward and multidisciplinary teams (16).

A strength of this study is the multicenter design and high response rate on all three patient questionnaires, which enhances the representativeness of our findings. Besides, we were able to include a broad range of clinical disciplines from different types of hospitals, which increases the generalizability of our findings. We included 15 wards in teaching hospitals and 19 wards in non-teaching hospitals. This is approximately in proportion with the Dutch situation; 36 teaching hospitals and 60 nonteaching hospitals (24). Although we have not selectively recruited the wards, most of the included wards were from a surgical (sub)specialty. There are no exact data about the number of PAs who are employed specifically for the management of hospitalized patients per clinical discipline, but we know that, in the Netherlands, most of them are employed at a surgical department. Some clinical disciplines, like internal medicine and obstetrics/gynecology were however not represented at all. It is not clear whether our results can be extrapolated to those disciplines.

A limitation is the non-randomized design of this study. Different from other countries, the Dutch PA programs incorporate a dual work-education

model, which means that students are employed within a particular medical specialty from the day of their enrollment in the master's PA program (25) (26). After graduation, the majority of PAs continue employed at the same department. The suggestion of randomly relocating the graduated PA to other hospital wards was considered not feasible for the staff physicians, who put considerable effort and time to training and supervision. The nonrandomized character of this study implies an increased risk for confounding, which we took into account in the multivariable analyses. However, we cannot exclude that local differences like policies about quality of care and patient case-mix could have influenced our results. To explore heterogeneity within our data, we conducted subgroup analyses for the four organizational models for medical ward care separately. Although the results of subgroup analyses should be interpreted with caution because of low numbers of patients per subgroup, several findings are intriguing. Significant differences in favor of de model in which only medical specialists were involved were found regarding the indicators the incidence of hospital infections, pressure ulcer, episode of two days body temperature ≥38, and episodes of two days Numeric Rating Score ≥7.

This might indicate higher quality of care within this model. We cannot exclude that this indicates that the patients which were included in this model were overall less complex than the patients in the other models. Although we've adjusted for relevant confounders in the multivariable analysis, it is not possible to perfectly adjust for the complexity of the patient. Further research should explore the cause of the difference.

We also performed separate analyses for surgical specialties only and non-surgical specialties only. We found significant differences for some indicators for quality and safety of care that were not consistent in favor of one of the study arms. Remarkably, the difference in patient evaluations between the study arms remained for the subgroup with surgical specialties, but not for the subgroup with non-surgical specialties. Reasons remain however speculative.

## Conclusion

This study suggests that care on wards managed by PAs is not different from the care on wards with traditional house staffing by MDs. Employing PAs seems to be safe and seems to lead to better patient experiences.

**Contributors** MGHL and MJCT are responsible for the design of the study, with comments of AJAHvV, MW, EA and GTvdB. MJCT

is responsible for the data collection and data management, with direct supervision and feedback from MGHL.

MJCT and EA conducted the data analyses. CLHvB, KvB, WWB, LJ, AV and FJvdW were involved in the data collection of the study. MJCT wrote the first draft of the manuscript, and all other authors reviewed this critically. All authors read and approved the final manuscript.

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# 5

# Physician Assistant and Nurse Practitioner General Practice Employment in the Netherlands

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## Abstract

General practitioners (GPs) are the cornerstone of primary healthcare in the Netherlands. As a national strategy, nurse practitioners and physician assistants were introduced to address a growing demand. Four representative practices were analyzed quantitatively and qualitatively; two solo practices with a PA or NP and two group practices with a PA or NP. A reference group of GPs served as experts. The annual encounters per full-time GP averaged 6,839, for the NP 2,636 and the PA 4,926. Billable services were 70% to 100%, averaging 71% for NPs and 85% for PAs, and in 3 of the 4 practices, the employment of the NP or PA was cost-efficient. The qualitative data show that the PA and NP contribute to general practice, easing the workload so that the GP has more time for complex patients. In doing so, the employment was financially beneficial in 75% of cases.

## Background

General practice or primary care is a vital component of contemporary medicine worldwide and the largest specialty of most healthcare systems (1). It is vital because primary care is central to a person's healthcare. Furthermore, maintaining an efficient and accessible general practice is essential to how the patient perceives this care (2)(3).

In many countries, general practitioners (GPs) are the foundation for meeting the growing demand for care due to aging populations, progressively complex patient needs, and expanding treatment possibilities (1). As the World Health Organization acknowledges, primary care is essential to address the needs of patients and people (4).

As for the Netherlands, the policy is for every resident to register as a patient in general practice (5). In all non-critical health problems, the patient consults their GP first. For the most part, the GP oversees various conditions, varying from common ailments to chronic diseases, and manages the patient longitudinally. When more complex problems arise, the GP serves as a 'gatekeeper' and refers the patient to an appropriate medical specialist in a hospital or ambulatory care setting (1).

Within the Netherlands, approximately 13,000 GPs are clinically active across about 5,000 general practices (5). A patient visits his or her GP office on average 4.3 times a year (6). Most (92%) new health problems present in the primary care practice (7). In the aggregate, the healthcare provided by GPs contributes to efficient and low-cost services with a high patient satisfaction rate (8). The biggest challenges to general practice care in the Netherlands are the high workloads and long hours (6)(9).

General practices in the Netherlands are organized under two structures: a GP physician as the practice owner (self-employed) or an association consisting of several GPs as salaried employees (10). In the first case, the GP is directly responsible for the business results as an entrepreneur, and the GP's income is derived from the practice results. In the larger organizational model, GPs are contracted employees. Although there is a trend toward more group practice arrangements, most Dutch GPs work in small practices of three or fewer (11). Evenings and weekend services are separately organized and not included in this study (12)(13).

Since the new century, physician assistants (PAs) and nurse practitioners (NPs) have been included as medical care providers in the Dutch general practices (14). The central drivers for this change are universal; the increased demand for healthcare due to an aging population and the shifting of low-complex, specialized medical care from hospitals to general practices (15). The introduction of PAs and NPs in 2001 was a

national strategy to reduce the workload of GPs and other specialties and to provide more cost-effective care (2)(13)(16).

Worldwide, evidence has been accumulating about the usefulness of PAs and NPs and their quality of care (17)(18). However, the financial and organizational benefits of employing PAsand NPs in general practices have yet to be thoroughly investigated (13). We set out to examine whether the employment of a PA or NP can benefit the GPs' workload, both quantitative and qualitative. The research questions are two-fold:

- *What are the financial aspects of PA or NP employment in a GP practice?*
- *Does the employment of the PA and NP in a GP practice have benefits beyond financial ones?*

## Methods

A descriptive study and a mixed-methods approach were selected to explore PA and NP employment in representative general practice arrangements. The intent was to identify the contribution that the PA or NP was providing to the production and workload of the GP. A second focus was on the employment costs of an NP or a PA and their financial benefit as employees in terms of ROI.

### Study sample

Four representative types of practices were selected based on input from an advisory group.

a) Self-employed GPs with a direct personal financial interest in an NP.
b) Self-employed GPs with a direct personal financial interest with a PA.
c) A group GP practice in which the GPs are contracted, employing an NP.
d) A group GP practice in which the GPs are contracted, employing a PA.

The selection of practices that met the inclusion criteria was a purposeful sample drawn from a list of Dutch practices employing at least one PA or NP (19). Criteria were the employment of an NP or PA for the last two years, the staff agreeing to interviews, GPs willing to provide financial and organizational practice data, and the practice willing to make available patient care data. The selection was completed when four candidate practices were willing to participate and met the inclusion criteria. Due to the sensitivity of the data requested, the funds available, and the amount of work to collect and analyze the data, the project was limited to four practices that could represent the range of interest.

We invited family physicians to form a reference group to maintain a grounding in our work. All were recruited from the Medical School's GP training program. In total, 13 GPs agreed to be a part of the reference group; seven solo practices (employing 3 PAs and 4 NPs) and six associated or group practices (four employed a PA and two employed an NP). The medical school associated GPs served as a content validation measure to determine whether the results from the four practices were generalizable.

The practice data was collected in 2018 (**Table 1**).

**Table 1.** Description of Variables and Data Sources

| | Quantitative Data | Qualitative Data |
|---|---|---|
| GP single-owner practice with NP | Extraction data from patient-information-system<br>Reimbursement information:<br>• Number of enlisted patients<br>• Number of visits<br>• Classification of complains | Interviews with GP, PA, NP, PCN, GP-assistant, and managers:<br>• Task profile<br>• Effects of employment<br>• Financial effects<br>• Working hours and workload |
| GP single-owner practice with PA | | |
| GP in association with NP | Information about personnel:<br>• number<br>• hours per week<br>• salary<br>• function<br>• roster data | Interviews with NP/PA<br>• Task profile<br>• Motivations<br>• Barriers<br>• Working hours |
| GP in association with PA | | |
| Validation | A group of 13 GPs provided their experience with the NP/PAs. The 13 GPs represented seven solo practices (employed 3 PAs and 4 NPs) and 6 GP associations (employed 4 PAs and 2 NPs) | |

## Data collection

### Qualitative data

To obtain information on quality, accessibility, patient experience, and workload, we interviewed clinicians and support staff. The data were enriched with roster details and information on the practice operation. In total, 23 individual interviews were held, and between five and eight interviews were undertaken with each practice. The interviewees included the solo GPs and at least two GPs in the group practices. Each employed PA or NP was interviewed. In addition, the GPA, MA, GPN, GPM, and, where available, a GP resident or NP student were interviewed (**Table 2**). Participation was voluntary, and none were compensated or rewarded for their contributions. None of the interviewees declined, dropped out,

or refused to answer questions. One of the two researchers/interviewers recorded all interviews individually and coded and matched them for consistency. Following the interviews, the codes of the two researchers (AK and YG) were compared and discussed until a consensus was reached (20).

**Reference group**

The findings from the four GP practices were presented to a reference group of 13 GPs to affirm that the sampled practices were typical and not distorted by confounding. This reference group, drawn from a university medical school, reflected on the findings throughout. The discussion with the reference group, led by an independent chair, focused on the results of the practices examined and then compared to the 13 general practitioners. The opinions, ideas, and beliefs about whether these four select practices represented Dutch GPs were recorded.

**Quantitative data**

To understand the effects on production and calculate the ROI, medical and financial quantitative data were collected, as quantitative information about the employment of the PA or NP. The procedures, patient schedules, patterns of business, and annual reports supplemented the administrative data. These data were used to calculate the ROI component of this study. In the Netherlands, GPs use a standardized computer system to administer and store patient encounter data. The electronic General Practice Information System (GPIS) consists of routine care, health insurance information, morbidity information, history of contact with health providers, and patient information. The GPIS-linked administrative and encounter data is used to submit billable claims to health insurance companies to reimburse services and registries for research purposes (21). The four practices made its GPIS available to the research team, including financial and patient care data. The quantitative data was extracted from the GPIS for enrolled patients, the International Classification of Primary Care codes (ICPC), and the number of visits per day, week, and year correlated with the type of provider. The patient's reason for a visit (e.g., presenting complaint) was compiled separately. In addition, the reimbursement returns and other financial data were extracted from the practice's information system or derived from the business operations. To gain insight into the pecuniary aspects of a GP practice, the financial data for 2018 were examined as the most recent year of the research. In Practice #2 (P2), the PA worked clinically for eight months in 2018, and the data was extrapolated to 12 months.

A central focus was the labor costs and benefits associated with the NP or PA and their contribution to the overall production in each GP setting. Therefore, we included data on personnel information, the number of employees, employee function, hours worked per week, salary, and roster (i.e., schedule information) from the information system. In interviews, we gathered information on task profiles, workload, working hours, motivations, and barriers to their employment. The billable revenues generated by the PA or NP relevant to their employment were assessed. The data obtained from the GPIS of the four practices were also obtained from the 13 GP practices that served as the reference group for validation purposes.

## Data analysis

All qualitative data from semi-structured interviews were recorded, transcribed, coded, and processed in *Atlas.ti* (a computer program for qualitative data analysis). A coded list of questions was developed before the interviews, and the codes were used to compare transcribed responses.

### Return on Investment

The return on investment (ROI) of adding an employee to a practice was viewed as a straightforward but key measure of profit derived from the investment (employment). This measure was used to evaluate the rank attractiveness of this new hire in terms relative to its cost.

All quantitative data were extracted from the GPIS. The total production of the practice and the production of the GP, PA, or NP, along with the overall financial turnover, were analyzed based on ICPC and were calculated as part of the general practice characteristics. The financial annual effects of employing a PA/NP were calculated using billable care as income generated by their employment, and the costs were salary costs, including 35% overhead. The cost of education or training was not included as the government finances health professional education and universal health care insurance.

The Return on investment (ROI) was calculated as follows:

$$\frac{\text{Net Return on Investment}}{\text{Cost of Investment}} \times 100\%$$

Next, the quantitative and qualitative data were presented as preliminary findings and discussed with the GP reference group. A set of validated results were agreed upon and advanced as reportable.

## Results

### Characteristics of General Practices

The number of GPs ranged from one to five in general practice offices, and the FTE of the GP ranged from 0.58 to 1.00 (**Table 2**). The FTE for the PA ranged from 0.78 to 1.00, and the NPs from 0.58 to 0.95.

**Table 2.** Characteristics of Assessed General Practices

| | Practice #1 with one NP (One GP as owner) | Practice #2 with one PA (One GP as owner) | Practice #3 with one NP (Association of GPs) | Practice #4 with one PA (Association of GPs) |
|---|---|---|---|---|
| Number of enrolled patients | 2,262 | 4,235 | 9,805 | 4,912 |
| Number of General Practitioners in FTE | 1 (1.0 FTE) | 4 (2.3 FTE) | 5 (3.9 FTE) | 2 (1.3 FTE) |
| Number of NPs in FTE | 1 (0.58 FTE) | – | 1 (0.95 FTE) | – |
| Number of PAs in FTE | – | 1 (1.0 FTE) | – | 1 (0.78 FTE) |
| Number of Interviews | 5 | 5 | 8 | 5 |
| The practice arrangement of the interviewee | 1 GP<br>1 NP<br>2 GPA<br>1 GPM | 1 GP<br>1 PA<br>1GPA<br>1 PCN<br>1 GPM | 2 GPs<br>1 GP resident<br>1 NP<br>1 student NP<br>1 PCN<br>1 MA<br>1 GPM | 1 GP<br>1 PA<br>1 GPA<br>1 PCN<br>1 GPM |

GP = General Practitioner; NP = Nurse Practitioner; GPA = General Practice Assistant; GPM = General Practice Manager; PCN = Primary Care Nurse, FTE = full-time equivalent; MA = Medical Assistant.

Across the four practices, the patient census ranged from 2,262 to 9,805 (mean of 5,303). The number of empaneled patients per full-time equivalent (FTE) GP was 2,599 (1,841–3,778). When the NP or PA was added to a GP practice, patients per FTE provider (GP, NP, or PA) averaged 1,774 (1,283 to 2,315 patients). The average number of consultations (encounters), home visits, telephone sessions, and procedures performed by GPs over the four practices per year converted to FTE was 6,839; for the NP, it was 2,636 per FTE and 4,926 for the PA per FTE. The list of

ICPCs was 1,257 diagnoses and spanned a broad spectrum of conditions. All four practices had similar patient populations and diagnoses. The most common conditions seen by GPs, PAs, and NPs were musculoskeletal, dermatological, and respiratory disorders. The two PAs saw a broader range of patient diagnoses within the four practices than the NPs (GPs averaged 493 unique ICPCs, PAs 369, and NPs 205). However, the NPs in both practices were involved with more time-consuming elderly patients than the GP and the PA. Table 3 summarizes the number or span of ICPC diagnosis codes the GP and the NP or PA saw in the four practices.

**Table 3.** Number of different ICPCs Diagnoses in 2018

| Practice | | Number or span of ICPC diagnoses | Percent of PA or NP ICPC diagnoses Compared to the GP |
|---|---|---|---|
| Practice 1 | NP | 263 | 58% |
| | GP | 455 | |
| Practice 2 | PA | 401 | 77% |
| | GP | 523 | |
| Practice 3 | NP | 146 | 25% |
| | GP | 589 | |
| Practice 4 | PA | 336 | 83% |
| | GP | 405 | |

ICPC = International Classification of Primary Care.

### Implications of PA and NP Employment on GP's Workload

Based on the interviews, the practice staff's most frequently mentioned effect of the new PA or NP was that each could offset the workload demands of the practice, giving the GP more time for complex patients. The division of labor resulting from their employment implied better productivity and improved efficiency, which appears to have increased GP job satisfaction. The increased time for the patient as a result of the new employee was mentioned by the staff but not quantified.

Some of the comments about the qualitative aspects of the PA/NP were:

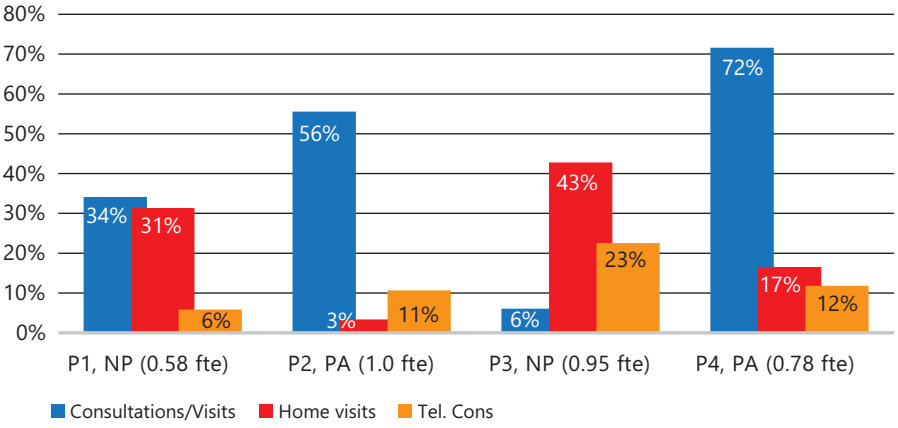
- GP2: "[The PA provides] less stress for the GP and more relief of workload with more time per patient and more time for management tasks."
- PA2: "[The PA] helped [alleviate] the increase in work pressure for the GP."

- A comment from the GP reference group was that the NP or PA seems to know their boundaries or role well.
- A comment from a GP was that the NP or PA had more time per consultation than a [typical] GP. This time was perceived by the patient and staff as a quality of care enhancement.
- Another comment was that a solo practice lacked the time commitment to train or guide [on-board] the PA or NP.

### Return on Investment

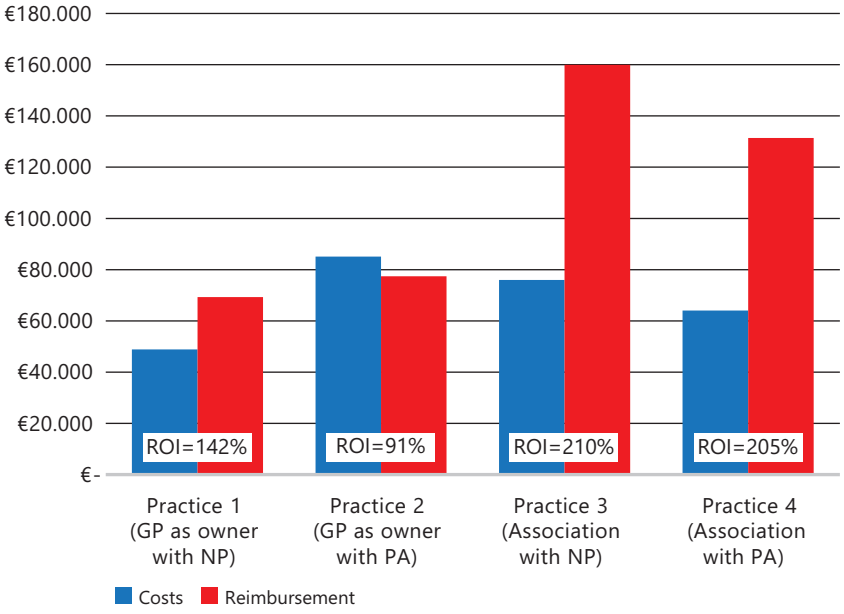
The productivity of the NP and PA expressed as a percentage of billable services (i.e., consultations, home visits, and telephone consultations) was 70 % to 100%, with an average of 71% for the NPs and 85% for the PAs. The 'Other' tasks were non-billable aspects of care, such as completing forms, insurance concerns, and addressing administrative issues. NP utilization involved more in-home visits and telephone consultations than the PAs who primarily provided care during consultations (**Figure 1**). Except for the fourth practice (P4), about 30% of the tasks were 'Other.' There were no traceable differences where the GP was the owner of a practice or to group practices.

**Figure 1.** Percentage Billable Production in 2018




The ROI of PAs and NPs was positive in three practices (**Figure 2**). In Practice 2 (one GP and one PA), the PA's employment costs exceeded the PA's revenue with an ROI of 91%. This was due to a relatively large portion of the PA's duties (approximately 30%) being administrative, not billable, and a relatively high salary.

**Figure 2.** Cost and Reimbursement: PA and NP in 2018




In Practice 3, the NP often managed elderly patients where additional reimbursement was given for home visits. In Practice 4, the PA mainly performed consultations that differed in quantity and diversity, at least from those of the GP within the same practice.

**Content validation of the reference group:**

After collecting and analyzing the data from the four case studies, focus interviews were also undertaken with the GP experts. In the validation or reference group, 10 of the 13 GPs had experience with an NP or PA in their practice. An overview of the characteristics can be found in **Table 4**.

**Table 4.** Characteristics of GPs participating in the reference group

| | Practice | Number of NP or PA's | Number of enlisted patients |
|---|---|---|---|
| GP A | GP as owner | 2 PAs | Unknown |
| GP B | GP in association | 1 PA | 5.000 |
| GP C | GP in association | 2 PAs | 140.000 |
| GP D | GP in association | 2 NPs | 2.300 |
| GP E | GP as owner | 1 PA | 5.000 |
| GP F | GP in association | 2 NPs | 9.000 |
| GP G | GP as owner | 1 NP | Unknown |
| GP H | GP in association | 3 NP | Unknown |
| GP I | GP in association | 2 NPs | 3.500 |
| GP J | GP in association | 4 NPs | Unknown |

GP= General Practitioner, NP = Nurse Practitioner, PA = Physician Assistant

**A summary of comments made by the GP reference group:**

- Reduction of workload and patient panel growth were recognized reasons for hiring an NP or PA.
- The diversity in the background and work experience by the PAs and NPs was considered in the hiring interview.
- The characteristic that stood out most was that the NP and the PA had a broad range of caseloads across all age groups.
- The NP's role often involved elderly care and long-term care more than the PA's role.
- One comment from the representative GPs was that PA and NP onboarding could take up to 1.5 years to achieve maximum employment.
- In addition to productivity, sharing the workload, and a sense of collaboration, many suggested another provider (PA/NP) could be considered to handle a growing caseload. This added clinician factor could not always be calculated into maximum production gains but was noted by many interviewees as an attribute that could improve office flow even more.

## Discussion

Analyzing the broadly drawn data from four Dutch general practices seems to have revealed the subjective value of an employed PA or NP on GPs' workload and the objective value of the ROI. At the same time, there

appeared to be no difference where the GP was the owner or a GP group practice. In the aggregate, each of the PAs or NPs was productive and saw many patients. Clearly, the NP and PA were value-added and helped to reduce the GP's workload. In three of the four cases, the ROI was positive. In Practice 2, the PA was engaged more in improving the administrative aspects of the practice early in his employment and, consequently, decreased reimbursable productivity. However, the organizational improvement activity was considered temporary, and later the PA was focused full-time on patient care.

The gathered data in this study shows a division of labor in the annual output of services that involves a PA or NP in a typical Dutch general practice. The effect on workload is attributed, as evidenced by the interviews with GPs, to the fact that an NP or PA accounts for some of the productivity, which is supplemented by performing additional tasks. These aspects have alleviated some of the perceived workloads of the GP. It should be noted that three practices enrolled more patients than the national average of 2,085 patients per 1 FTE. While the results are confined to four out of 500 GP practice settings in the Netherlands, they are potentially representatively, broadly speaking, of how GPs could benefit financially and subjectively by employing PAs and NPs.

Understanding the favorable effect of incorporating a PA or an NP in a medical practice is a growing health professional labor topic spanning Europe and North America (22)(23). For example, Halter and colleagues in the UK found that PAs were increasingly used in significant medical consultation roles in primary care (24). Pany and colleagues (2021) validated a series of studies in the US that team-based care produces better outcomes than solo practitioners (25). Leach and colleagues (2017) noted that the results of patients with chronic diseases treated by PAs, NPs, or doctors revealed no differences suggesting that a broad range of care can be collectively managed by PAs, NPs, and GPs (26). In addition to their reimbursed productivity, our study showed that the NP and PA also saw a wide variation in patient conditions; the PA saw 75% of the same conditions relative to a GP and the NP 42% of the GP. The consensus of the reference group was that this addition to the staff contributed to offsetting some of the GP workload.

The literature on PA and NP employment ROI is scarce. However, two systematic reviews on NPs and PAs spanned 72 cost-effectiveness studies (18)(27). The reviews concluded that NPs and PAs are cost-effective in most employment cases, either as a physician substitute or as a complement to improve care output. The ROI was positive in the few instances where it

was calculated due to the relatively high productivity for which revenue was obtained compared to wage costs.

The observations of primary care in the Netherlands, where PAs and NPs are increasingly utilized, find their employment valuable (17)(28). Such findings are seen globally (25)(29)(24)(30). What works best for one clinician or practice is copied by others – but perhaps more importantly, the best practice policy tends to affect all providers. In adult medicine, the PA or NP produces the same outcome as the GP, suggesting that best practices are emulated.

### Strengths and Limitations

This study has several limitations. The question is whether a dual distinction of a self-employed GP and a group practice of GPs do justice to all the organizational differences in GP practices. To this end, we validated the generalizability of findings with a sample of GPs. The reference group confirmed that the outcomes of the four practices could be comparable to the approximately 500 GP practices in the Netherlands. A note was added that the 1-year familiarization period, as the inclusion criterion in this study, may be on the short side, and the effects of employability could improve after a year or two. Although relevant topics such as quality of care and patient satisfaction were not measured directly in our study, however, previous studies have shown positive effects of NP or PA employment on Dutch patient satisfaction with at least equal or higher quality of care compared to care provided by physicians (17)(18).

All practices and the 13 GPs in the reference group were created through purposeful sampling with voluntary participation. This method has a risk of bias given the broad aspect of the research questions. More critical details such as observing patient-provider interactions, time-motion studies, the role of general practice assistants or primary care nurses, and the effect of other office staff were the economic tradeoffs for the bigger picture.

A strength of the current study is the large number of interviews with different professionals and the in-depth answers we received. In addition, the participants came from a wide geographic area, and the variation in types of practices was thought to reflect the distribution of practices in the Netherlands (9). Another strength is that the interviews were conducted in a semi-structured manner consistent across the four practices.

We have constructed a general representation of the activity of GPs employing a PA or an NP in the Netherlands. More importantly, the global movement reflects the work to include PAs and NPs in family medicine

(31). Finally, this undertaking intended to set the stage for a more granular examination of activity in general medicine, how it expands to accommodate a change in the healthcare landscape, and move research to care outcomes.

## Conclusion

Since introducing the PA and NP in Dutch healthcare, primary care practices have grown. The employment of NPs and PAs comes at a time of increased demand, the aging of the population, and more complex care needs. This results in more frequent and prolonged visits to the general practice. We analyzed four representative general practices that employ PAs and NPs. Solo and group practices using PAs and NPs are productive primary care team members and worthwhile staff additions in each case. In all four GP practice analyses, the employment of the Dutch PA and NP made a valuable contribution to the practice flow while reducing the workload of GPs. In three of the cases, the ROI was positive. In the fourth case, the PA performed additional management tasks, which led to a negative ROI. Nonetheless, employment was evaluated as a positive contribution to general practice care. More robust research in a larger sample is needed to draw firmer conclusions.

### Availability of data and materials

Due to ethical and legal policies, the raw data cannot be made publicly available. However, all interested readers may request data from G. van den Brink for additional information.

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### Competing interests

The authors declare that they have no competing interests.

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**Ethics approval and consent to participate**

The Radboud University Medical Center Research Ethics Committee, Nijmegen, approved the research protocol. Informed consent was obtained from all subjects.

**Guidelines and regulations:**

All methods were carried out following relevant guidelines and regulations.

**Competing interests**

The authors declare that they have no competing interests.

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# 6

# Discussion & conclusion

## Discussion

Adding new healthcare professionals, such as physician assistants (PAs) and nurse practitioners (NPs), to augment medical staff shortages has been a strategy to improve healthcare service delivery for half a century (1-3). Their presence is in the USA, Canada, the United Kingdom, the Netherlands, and a dozen other countries (4). In the Netherlands, the PAs and NPs are employed on the wards as hospitalists, in outpatient services, in general practices, and in elderly care (5)(6). The Dutch government widely supported the introduction of the two new professionals in funding the education and preparation of both (7). Following a series of reports, the new professions were given full authority to perform medical tasks relatively quickly (8)(9).

While a fair amount is known about the quality of care provided by the NPs and PAs, relatively little is known about the proportion of direct patient care, the cost-effectiveness of their care, and the general effects on workload service delivery.

In this thesis, we gathered further evidence on these topics. The research in this thesis was performed in the Netherlands within primary care and hospital settings. The central aim of this dissertation was to determine the contributions of NPs and PAs in the Dutch healthcare system. In this thesis, the research question centers on the effects of the employment of the PA or NP on Dutch society. This effect is measured against the quadruple aim as defined by WHO: to improve the health of populations, to improve

patients' experience of care, to reduce the per capita cost of healthcare, and to improve the working lives of healthcare professionals and staff (10).

Three empirical studies and one systematic review describing the broad literature on PA effectiveness were undertaken to answer this research question. The empirical studies include: 1) PA and NP hospital ward services were examined in terms of tasks, 2) mapping the effectiveness of a PA on a hospital ward, and 3) documenting the economic benefit of NP and PA employment in general practices. The systematic review focused on international literature the economics of PA employment in various healthcare settings.

In summarizing the studies, the main findings were clarified, methodological issues discussed, recommendations for practice and policy were made, educational training was mentioned, and where the next focus of PA and NP research should occur. Each finding and result is a set of published studies in the biomedical literature. The information adds to the growing research that informs Dutch society that the health policies enacted by the government have produced a social benefit.

## Main findings

- The effects of PA employment in different settings are the same or better care outcomes as physicians with the same or less cost of care. Sometimes this efficiency was due to their reduced labor cost and sometimes because they were more effective as producers of care and activity (chapter 2).
- The different patient-related task areas of the PA and NP in hospital services and clinics have a wide variety, the coherence of these tasks varied by medical specialty, and MDs and managers indicated in the interviews that the use of an NP or PA was considered an added value. The contribution of NPs and PAs in the direct patient care has become more visible which in turn leads to more reliable assessment of the activities as an important condition for the communication about their worth to the hospital and a further implementation of these professions (Chapter 3).
- The cost-effectiveness of the PA in the Dutch hospital wards compared with physicians is not different from the care on wards with traditional house staffing by MDs. Employing PAs seems to be safe and seems to lead to better patient experiences (Chapter 4)
- The employment effects of the PA and NP in Dutch general shows that PAs and NPs in solo and group practices are productive primary

care team members. In all GP practice analyses, the employment of the Dutch PA and NP made a worthwhile contribution to the practice flow while reducing the workload of GPs.
- The return on investment of the PA and NP in Dutch general practices was in 75% of the cases positive.

## Discussion of the main findings

The main findings will be discussed using the quadruple aim.

### Population health

Little research has been undertaken on health improvement at the population level when an NP or PA is introduced to a system such as a GP practice or hospital ward. Health improvement is defined as the health outcomes of a group of individuals, including the distribution of such results within the group (11). The systematic review described in Chapter 2, consistent with what Morgan et al. (2019) found, was that when caring for a particular group of patients, such as veterans with diabetes or cardiovascular disease, a PA and NP as the primary provider of care improve the outcomes of care by better use of the multidisciplinary team and adhered more closely to guidelines than physicians in the same setting (12)(13). In complementary studies, Showstark et al. (2022) and De Bruijn et al. (2018) described these phenomena as an effect of the professional attitude of the PA and NP (13-15). Finally, in the "Primary Care Plus" (post-hospital care) study, the outcome of the employment of the NP improved access to care facilities for the aging population (16).

### Patient experiences of care

In the empirical studies included in this thesis, no direct effects on quality of care were measured, but data on quality of care were obtained from interviews. These outcomes are consistent with the results from the studies included in the systematic review (Chapter 2) and similar systematic reviews on the effects of NP employment (17-19). The quality of care and patient satisfaction remained the same as physicians when the employment of the PA was added to a health system. In some cases, patient satisfaction even increased (Chapter 2). For the NP, comparable studies revealed the same (17-19).

Functional analysis of NPs and PAs (Chapter 3) shows that Dutch NPs and PAs perform a wide variety of clinical tasks, and the consistency of these tasks differs per medical specialty. Interviews with MDs and managers

revealed that the employment of an NP or PA was assessed as an added value (21). This value was centered on the quality of care at the patient level.

In Chapter 4, we saw the increased care continuity on the ward with the added presence of a PA. While this new provider had a marginally higher length of stay (LOS) compared with the medical specialists' model, the outcome was improved satisfaction, and care was optimized. Although many variables were held constant in quality-of-care assessments, factors outside of traditional medical care may have influenced the outcome of the effects attributed to the use of the PA or NP. This added value phenomenon occurs when comparing care delivered by physicians and by an NP or PA is not measured simultaneously (22).

However, perhaps more importantly, the indirect gain from the employment of the PA was examined in the hospital ward study in the application of 'quality-adjusted life years (QALYs). This was a downstream and long-term assessment of whether the intervention of a patient's condition amounted to some benefit by one provider over another. The finding was that no statistical differences emerged in QALYs when the physician or PA was involved (23) (Chapter 4). This finding was in line with our systematic review (Chapter 2), which showed that studies on clinical outcomes and patient satisfaction in hospital care showed that NPs and PAs are equal to MD-provided care or, in some instances, more favorable outcomes (Chapter 2)(24). Other research (13)(15) also showed similar effects. For example, it was noted that emergency NP service positively impacts the quality of care, patient satisfaction, and waiting times (23). Patients in hospitals with higher NP-per-bed ratios were significantly more likely to report better care quality and safety (25).

**Reducing costs of care**

When the financial impact of employing an NP or PA is searched for in the literature, the findings are limited (Chapter 2). Using a PA or NP in the Dutch healthcare system does lead, in most cases, to cost savings in direct personnel costs (Chapters 3, 4, and 5). While their annual productivity seems similar, depending on the type of setting, medical or surgical specialty, and geographical location (26), what is known is the organizational benefit of when either type of provider is added to the team.

The PA's utilization in hospital wards was cost-effective compared with physicians because of the lower labor costs (Chapter 4). The increased provider continuity on the ward with the added presence of a PA did not decrease the overall healthcare costs in one small regard because the length of stay (LOS) was marginally higher than the medical specialists' model.

However, it should be noted that the comparison of service delivery and use of resources did not significantly differ between the PA models and the model that involves only residents. These observations suggest that the cost-effectiveness of inpatient care delivered by a PA-based team is comparable to that of resident-based groups. In the systematic review (Chapter 2), three studies described PA employment related to an increase in LoS, and three found no difference in length of visit (LoV) or LoS. In 17 studies, the employment of the PA led to a reduction in total healthcare costs.

The cost of care, in monetary terms, measured in 11 studies, decreased with the introduction of a PA, or the results were equal to that of a physician alone. Rarely did these studies examine the broader organizational effect of whether adding a provider improves overall organizational efficiency (Chapter 2). Drennan et al. (2014) point out that when the PA's service was incorporated into the cost-effectiveness analysis, this addition could have a broader impact on the cost of health services through referrals and prescriptions (27).

The return on investment of the PA and NP in Dutch general practices was, in most cases, positive; in the aggregate, PAs, and NPs were productive additions to the practice and saw many patients (Chapter 5). Functional analysis of NPs and PAs showed improved hospital-based medical care production (Chapter 3). The PA performed 62% and the NP 55% of their working time on clinical tasks previously performed exclusively by physicians (i.e., task substitution and delegation combined). Early observations by Zwijnenberg & Bours (2011) described that NPs spent 25% and PAs almost 50% of their time on medical procedures/tasks in a context where most of the NPs and PAs experienced barriers in the reallocation of duties or functions they were trained to undertake (28). A study within Dutch hospitals demonstrated cost-effectiveness, in 11 out of 13 cases, the employment of a PA or NP was found to be cost-effective (29). The Dutch study by van Voorst et al. (2022) compared the costs of the employment of a PA or NP with the employment of residents or medical specialists. It seems that the NP and PA can perform additional tasks or assume a wide range of traditional physician tasks at the same cost without capitalization of the costs.

Overall, PAs and NPs are cost-effective in delivering patient care. Many medical specialists experienced increased efficiency in their service delivery because the NP or PA performs additional tasks, usually the responsibility of the staff physicians or residents. Examples include integrating newly employed doctors, performing specific (and at times complex) medical procedures, providing education to patients or trainees, or conducting quality projects (37).

**Healthcare team well-being**

In addition to improving quality and cost of care, the effects on health employment working conditions were also examined in this thesis. The employment effects of the PA and NP in Dutch general practices reduced the physician's workload and improved their job satisfaction (Chapter 5). In the study where the PA on the ward was compared to the standard MD model, one effect produced was increased provider continuity. Overall, the impact on workload is attributed, as evidenced by the interviews with General Practitioners (GPs), that an NP or PA accounts for some of the productivity supplemented by performing additional tasks. These aspects offloaded some of the workloads of the GP. It should be noted that three of the practices enrolled more patients than the national average of 2,085 per GP.

Satisfaction among physicians working with an NP or PA appears to increase (Chapter 2). These findings were also demonstrated in several studies (25)(29)(30). For example, the freed-up time for the physician by the new employment of the NP or PA was used for more complex patients while reducing the physicians' workload (29)(31). Nurses in hospitals with higher NP-per-bed ratios reported lower burnout, higher job satisfaction, and greater intentions of staying in their jobs (25). One overall impression from the added role of PAs and NPs is that the resistance among medical or nursing staff to introducing these professions seems to have largely disappeared.

Regarding job satisfaction, the effects on continuity of care are also a consequence of using an NP or a PA. At the same time, NPs and PAs are generally satisfied with their job performance. In turn, this new role has involved them more in patient care and greater professional satisfaction (5)(6)(32).

One of the questions that arise is whether there are significant differences between the employment of PAs and NPs in the same setting. Based on this work and others, some minor differences are revealed. In Chapter 5, it appears that the PA in a GP setting has a broader range of medical tasks and takes on a wider variety of patient problems, more like the GP, than the NP. On the other hand, the NP improves the practice quality of care by managing more vulnerable and elderly patients who have complex needs. These observations are consistent with other health economic studies on the medical workforce and imply there may be an optimal division of labor when both are part of a team effort to manage a population of patients (28)(33-35).

## Methodological reflections

When examining the effects of relatively new professions, several factors influence the findings. These factors are the combination of the introduction of an NP or PA with other organizational changes, not yet reaching an optimal use of the PA and NP due to unfamiliarity with the new profession, and a combination of substitution and additional tasks.

The introduction of an NP or PA combined with new developments or changes within an organization may lead to confounding outcomes analyses. Many studies have described the introduction effect of the NP or PA where additional staff deployment, additional training, or changes in work processes have co-occurred. This could lead to an overestimation of the effect of the new professionals.

On the other hand, the NP or PA's employment was not yet optimal in some research because of various barriers. Therefore, optimal productivity cannot always be achieved even when onboarding is enacted (36). This is especially true when they are placed in low-volume sites, have inconsistent patient contact hours, lack registration knowledge, and have a limited scope of practice (22). These factors contribute to a possible underestimation of the effects of employment.

Some PAs and most NPs have a combination of substitution- and additional tasks. In mapping the effects of employing a PA or NP as a substitute or complement to traditional physician services, it is not always possible or desirable to measure only the substitution effect. The NP and PA provide added care from their professional background and training. In addition, introducing these professionals is often accompanied by a different set of system interventions (11). In many situations, the introduction of an NP or PA was supplemented by a redesign of the care provided with some additional strategies of care at times (18)(37)(38). The NP or PA had more time per patient in some instances. This added more consultation time or, in some cases, specific training, which could affect the equation as substituted labor. Some improvements in the organization of care can be attributed to the introduction of an NP or PA as an increase in staffing availability.

On the other hand, the position of an NP or PA was not always optimally related to their competencies. Therefore, optimal production cannot always be achieved. This is especially true when they are placed in low-volume sites. Along with inconsistent patient contact hours, a lack of registration knowledge, and a limited scope of practice (22).

### Limitations

All health service research studies have some limitations. One shortcoming is the inability to blind the effects of the intervention (comparing a PA or NP to a physician) to the researchers. The consensus amongst researchers is that not disclosing the type of health professional providing traditional physician services is considered unethical.

In introducing the limitations of this undertaking, all the empirical research in this thesis was performed in the Netherlands healthcare system, hospitals, and general practice. Because of this, the results are of limited generalizability to countries and systems elsewhere. The studies included in the systematic review were all conducted across high-income countries within primary care and hospital settings. In comparison, conclusions apply only to this part of the world and limit generalizability.

In addition, research for primary policy development was used, which may have influenced the validity. The studies in this thesis cover six years, raising the question of whether all data obtained remain valid. We note that there have been no significant changes in the laws and regulations governing the duties or working conditions of the NP or PA since the data were collected.

The participants in the task analysis (Chapter 3) and the GP practices were selected by purposive sampling (Chapter 5). This could have introduced selection bias. Another limitation is the creativity of the study. We initiated the study with the policy issue as a starting point in both cases and conducted research. The bias is the advocacy for both professions, partly because the Ministry of Health and professional groups are interested in a good outcome. On the other hand, the advantage is that the research question has a high degree of validity to the many questions from daily practice.

### Strengths

One of the strengths was the number of interviews included in the task-analysis study and GP-study (Chapter 3 & 5). In addition to quantifying general practice information such as the appointment diary, the GP information system, and the financial system, many items were extracted. And on top of this list, the data were triangulated with interviews with PAs and NP, the employing GPs or MDs, and other support staff about the utilization, workload offset, and revenue gained from this new addition. In the GP study a focus group with GPs was convened to validate that the data collected was representative of a cross-section of GP practices (Chapter 5).

In the task analysis study (Chapter 3), a descriptive, non-experimental research design was used to collect and analyze quantitative and qualitative data about the type of tasks performed by a PA or NP. In the cost-effectiveness analysis of the PA on the ward in a multicenter setting, many PAs were observed across various hospital settings using a matched controlled design format (Chapter 4). This choice of different research strategies was considered a strength of the overall process.

Patient satisfaction with PAs was directly measured by interviewing each patient upon departure from their medical appointment (Chapter 4). The results of the included studies in the systematic review (Chapter 2) showed a wide diversity of measurements, so no meta-analysis was possible. On the other hand, the strength is a large number of articles from different countries and most studies published in recent decades and, therefore, the possibility to compare the findings with the research findings in the Netherlands (chapters 3, 4, and 5).

**Implications and recommendations for practice and policy**

In summary, the development and employment of PAs and NPs reveal how their introduction improves the general well-being of Dutch society. The work on this thesis, with the development and use of complex health services research, sets the stage for more penetrating studies where their employment can be optimized.

The introduction of the PA and NP professions into the Dutch healthcare system at the beginning of the new century has supported national health policy in several ways. One was to substantiate and initiate the procedure through evaluation research. The other was continuously promoting the importance of skill mix and the use of NPs and PAs by the Ministry of Health, Welfare, and Sport. This advocacy was coordinated with the Dutch professional association of physicians and the association of nurse practitioners. In addition, the Ministry of Health also supported the education process by providing financial support to the institutions where the PA or NP was in training (34).

The studies in this dissertation build on that policy research by exploring their role and utilization in Dutch society. With the result of studies presented here and elsewhere, a much larger picture of the utilization of PAs and NPs in the Dutch workforce is revealed. And with it, where more research is needed.

The world is beginning to understand that team uses in healthcare is inevitable. Team-based care has become the byword for Dutch healthcare service delivery, becoming the byword for over a dozen societies (14). For

the most part, PAs and NPs are employed as team members. To what degree teams of healthcare providers can improve outcomes that are satisfactory to all involved needs to be validated, but within the studies cited in this thesis, we have seen variation in how the PA or NP are employed within a specialty. The employment of an NP or PA changes the role of all healthcare providers involved. Moreover, the new division of labor, i.e., skill mix, must be tailored to the area of work of the NP or PA being employed and to the professionals who will work with the NP or PA (33)(39-41).

In the Netherlands, introducing PAs and NPs was an innovative policy that began two decades ago. Since that early introduction, its success has been measured in ways unanticipated. As a result, the recommendation for practice and policy as it applies to PAs and NPs is as follows:

Find the upper limits of the utilization of safe and efficient healthcare delivery when it involves PAs and NPs.

Despite a successful introduction and adoption, the Dutch NP and PA professions remain relatively small compared to a few other countries (9)(42). In addition, the PA profession lacks a significant and influential professional association embracing them as the NP has with the association of nurses. This implies that these professions need professional association support even after this successful introduction into healthcare. This seems especially true in areas of healthcare where these new health professionals are still relatively rare (e.g., elderly care, occupational medicine, and for PAs, also psychiatry).

**Implications regarding the employment of PAs and NPs**

NPs and PAs have an extensive scope of practice and strong relationships with patients and are valuable healthcare team members. In a health management environment where resources are scarce, NPs and PAs offer more flexibility to see patients without compromising quality or outcomes.

Because both professionals diagnose, treat, prescribe, and manage patient populations, they are often the primary care provider for patients and coordinators of care. NPs and PAs are found in various settings and assume many crucial responsibilities (43). Despite these similarities, the NP and the PA differ somewhat in their different educational tracks. NPs emerge from a nursing model that emphasizes the consequences of illness. At the same time, the PA has a bachelor's degree in healthcare in terms of prior education and training according to the medical model.

From the nursing model, it is easy to understand that holistic care, prevention, and health promotion are the guiding principles of an NP (44).

Traditionally, PAs focus more on medical care and have a broad generalist approach (45). But misunderstanding the role and value of the NP or PA persists in many organizations and strengthens barriers and thus prevents optimal deployment.

Since their introduction in the Netherlands, there have been more NPs than PAs. The NP profession seems to evoke less resistance when introduced into a health system, often from where they were employed as a nurse. Their internships are shorter compared to PAs. As a result, quite a few NPs end up in places that might better fit the profile of a PA. The result is often uncertainty for the NP or PA about continuing the job or job content and an unclear position in the organization (28)(42). A nuanced distinction between PAs and NPs is essential for sustainable employability so that one of each profession's profiles can contribute significantly to solving the increasing challenges facing the healthcare system in the coming decades. Any competing approach to achieve better professional positioning is likely to prove counterproductive.

The combination of multiple simultaneous changes taken when introducing a PA or NP leads to a murky picture of the effects of employment. In this light, the results should be measured as to all the changes associated with introducing any new autonomous (or semiautonomous) labor.

**Implications and recommendations for education**

The importance of population health in healthcare delivery is reinforced by an Institute of Medicine (2015) report indicating that health practitioners and facilities should invest in training for population health management approaches (46). A threat to the effectiveness of the NP or PA is the number of effects expected from their employment (27)(47). Goals are often linked to production, as a substitution effect, the improvement of quality, the increase of the continuity of care, and the performance of additional services. It is also expected that using the NP and PA will reduce the physician's workload and that the NP and PA will also be at least cost neutral but preferably much cheaper. Therefore, every NP or PA student must learn to set limits during their education and develop a clear vision of what effects the organization can expect from their employment. PAs and NPs need to make visible their contribution in terms of quality of care, accessibility of care, cost-effectiveness, and healthcare worker job satisfaction if their work is to be valued. These are aspects of professional development that educators and scholars of these health occupations should focus more on.

**Recommendations for future research**

The findings from this thesis addressed the research question: are PAs and NPs in society's best interest? Because this work builds on a growing body of published literature, the answer seems unequivocally positive. As a result, the evidence now points to several more refined questions. What is the maximum substitution of PAs and NPs in different service settings? What is the division of labor in teams built on MDs, PAs, and NPs? Are there efficiencies in PA/NP utilization that are being overlooked? Are there MD domains, such as radiology and pathology, that NPs and PAs should or could occupy? Time-motion studies could compare the daily activity of PAs, NPs, and MDs if we are to understand the implications of their employment as interactive members of a team. And finally, more outcomes research is needed. Outcomes that compare the productivity of different types of providers, their cost-utility, and patient satisfaction lead the list. Is there an optimal division of labor that includes all three working together?

## Conclusion

Historically, a common question that arises when a PA or NP is introduced in the healthcare system is whether these professionals with less training than a physician could provide comparable quality of care and if their care was cost-effective (19)(48-50). The results of this quartet of studies provide new insights into the effects of NP and PA deployment. The results, as well as results to date, are pointed in the same direction – society benefits when they are incorporated into healthcare service delivery. The quality of care is the same or even improved in most cases, and the deployment is cost-effective in terms of both care-related costs and labor costs. It is shown that the PA and NP function best as members of teams. They improve the well-being of patients in many ways and, at the same time, improve the workload and satisfaction of healthcare professionals. Many of the initial uncertainties surrounding the utilization of PAs and NPs have been addressed, and newer observations about their employment have been revealed in task transfer, patient satisfaction, revenue generators, and team partners. In this thesis, what consistently emerged is that, in addition to their already known improvement in quality of care, the employment of the PA or NP is economically beneficial in terms of physician satisfaction and as a return on investment for employers.

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# 7

# Summary

This thesis focuses on determining the contributions of Nurse Practitioners (NPs) and Physician Assistants (PAs) in the Dutch healthcare system. More specifically, this thesis is a description of the tasks performed by the NP and PA, as well as the effects on quality, continuity, costs, and job satisfaction. This thesis reports 3 empirical studies and one systematic review, the latter focuses on worldwide contribution of PAs to healthcare systems.

## Chapter 2

### The Cost-Effectiveness of Physician Assistants/Associates: A Systematic Review of International Evidence

This chapter describes the results of a Cochrane formatted systematic review of the literature on PA cost-effectiveness compared to physicians was undertaken. Cost-effectiveness was operationalized as quality, accessibility, and the cost of care. The method involved collecting literature from 1965 to 2022, which was searched across five biomedical databases and filtered for eligibility. Publications that met the inclusion criteria were categorized independently by date, country, design, and results by three researchers. All studies were screened with the Risk of Bias in Non-randomised Studies – of Interventions (ROBIN-I) tool. The search produced 4,855 titles, and after applying criteria, 42 studies met inclusion (34 North America, 4 Europe, 1 Africa). Ten studies had a prospective design, and 29 were retrospective. Only four studies were assessed as biased in results reporting. While most

studies included a small number of PAs, five studies were national in origin and assessed the employment of a few hundred PAs and their care of thousands of patients. In 34 studies, the PA was employed as a substitute for traditional physician services, and in five studies, the PA was employed in a complementary role. The quality of care delivered by a PA was comparable to a physician's care in 15 studies, and in 18 studies, the quality of care exceeded that of a physician. In total, 29 studies showed that both labor and resource costs were lower when the PA delivered the care than when the physician delivered the care. The most important findings were that PAs provided the same or better care outcomes as physicians with the same or less cost of care. Sometimes this efficiency was due to their reduced labor cost and sometimes because they were more effective as producers of care and activity.

## Chapter 3

### An activity analysis of hospital-based physician assistants and nurse practitioners

Chapter 3 presents the results obtained by a descriptive, non-experimental research method to collect and analyze quantitative and qualitative data on the types of tasks performed by a PA or NP in Dutch hospital settings. Fifteen medical departments across four hospitals participated. Two systems were probed to characterize the wide variety of clinical tasks and roles of PAs and NPs. These systems included the patient scheduling system and hospital information system identified. A total of 108 interviews were conducted to verify the inventoried tasks. All tasks were divided into direct and indirect patient care. Once the tasks were cataloged, MDs and hospital managers graded the PA or NP on performed tasks and assessed their contributions to the hospital management system. In total, 2883 tasks were evaluated. Overall, PAs and NPs performed a wide variety of clinical and administrative tasks, which differed across hospitals and medical specialties. Data from interviews and the hospital management systems revealed that over a third of the tasks were not properly registered or attributed to the PA or NP. This administrative flaw was brought to light as a systematic problem and no reflection on the PA's or NP's performance. What was found was that the NP and PA spent more than two-thirds of their working time on direct patient care. The consistency of these tasks differed per medical specialty, but even though a large part of the tasks was not visible due to the way the data was collected, the interviews with MDs and managers revealed that the use of an NP or PA was considered an added

value at the quality of care as well to the production for hospital-based medical care.

## Chapter 4

### A cost-effectiveness Analysis of physician assistants in inpatient care

Chapter 4 presents the substitution effect of inpatient care from medical doctors (MDs) to PAs. A quasi-experimental Matched Controlled Trial was to investigate the A cost-effectiveness within a multicenter hospital system. The traditional model in which only MDs are employed for inpatient care (MD model) was compared with a mixed model in which PAs are employed (PA/MD model). The observation of these providers occurred in 34 hospital wards across the Netherlands. Participants were 2,292 patients and followed from admission until one month after discharge. Patients receiving daycare, terminally ill patients, and children were excluded. Primary and secondary outcome measures and all direct healthcare costs from the day of admission until one month after discharge were tabulated. Health outcomes were assessed using quality-adjusted life years (QALYs), as measured with the EuroQol-5D five dimensions questionnaire. The result was that no significant difference emerged for QALY gain (+0.02, 95% CI −0.01 to 0.05) when comparing the PA/ MD model with the MD model. Total costs per patient did not significantly differ between the groups.

Regarding the costs per item, a difference of €309 per patient was found in favor of the MD model regarding length of stay. Personnel costs per patient based on the provider primarily responsible for medical care on the ward were lower on the wards in the PA/MD model. The conclusion was that the cost-effectiveness of wards managed by PAs, in collaboration with MDs, was like the care on wards with traditional house staff. The involvement of PAs may reduce personnel costs, but not overall healthcare costs of a single episode of care.

## Chapter 5

### The Effects of Physician Assistants and Nurse Practitioners on General Practice Medical Care in The Netherlands

Chapter 5 describes the effects of PAs and NPs in general practice medical care using a mixed method study in four representative practices drawing on annual patient encounter data supplemented by several interviews. In many Western countries, General Practitioners (GPs) provide

a pivotal role in healthcare delivery. With an aging population and care shifting from the hospital to the primary care setting, the GP workload grows. The employment of PAs and NPs are helping to offset the demand for primary care services. While research has shown the impact on the quality of care of PAs and NPs, there has been little impact assessment on workload and return on investment. The content and the effects of their employment on the workload for GPs and the return of investment were researched across four different types of GP practices in the Netherlands using a mixed methods approach. The method was a retrospective examination of general practices where a PA or NP was employed. Electronic data from the practice information systems were combined with interviews with GPs, PAs, NPs, practice support workers, primary care nurses, and practice managers. In addition, to investigate generalizability, a representative group of physicians from 13 practices participated as a reference group to discuss and validate the findings. The number of enrolled patients in each of the four practices ranged from 2,600–9,900. The annual output of each general practice included consultations, home visits, telephone consultations, and procedures. The billable production of the services was 69.6% to 100%, with an average of 71.4% for the NPs and 85% for the PAs. On average, the PAs saw a wide range of patients while NPs were more involved with fragile and elderly patients. In all four cases of representative GP practices, the employment of the PA or NP was satisfying; the workload of the GPs was alleviated to some extent, and throughout their employment, the growing demand for care was met with improved services. In terms of the direct financial return of their employment, three of the four practices were positive. Overall, the PA and NP positively affected GP workload reduction.

# Samenvatting

Dit proefschrift beschrijft de bijdragen van Verpleegkundig Specialisten (VS-en) en Physcian Assistants (PA's) in de Nederlandse gezondheidszorg. Meer specifiek wordt een beschrijving gegeven van de taken die de VS en PA uitvoeren, alsmede de effecten op kwaliteit, continuïteit, kosten en werktevredenheid. Dit proefschrift doet verslag van 3 empirische studies en één systematische review. Het review richt zich op de bijdragen van de wereldwijde bijdrage PA aan de gezondheidszorg.

## Hoofdstuk 2

### De kosteneffectiviteit van Physician Assistants: Een systematisch overzicht van internationale evidentie

Dit hoofdstuk beschrijft de resultaten van een volgens Cochrane richtlijnen uitgevoerde systematische review van de literatuur over de kosteneffectiviteit van PA's in vergelijking met artsen. Kosteneffectiviteit werd geoperationaliseerd als kwaliteit, toegankelijkheid en kosten van de zorg. De methode bestond uit het verzamelen van literatuur van 1965 tot 2022, die werd doorzocht in vijf biomedische databanken en gefilterd op geschiktheid. Publicaties die voldeden aan de inclusiecriteria werden door drie onderzoekers onafhankelijk van elkaar gecategoriseerd op datum, land, ontwerp en resultaten. Alle studies werden gescreend met de Risk of Bias in Non-randomised Studies – of Interventions (ROBIN-I) tool. De zoekactie leverde 4.855 titels op, en na toepassing van criteria voldeden 42 studies aan de inclusiecriteria (34 Noord-Amerika, 4 Europa, 1 Afrika).

Tien studies hadden een prospectieve opzet, en 29 waren retrospectief. Slechts vier studies werden beoordeeld als vertekend in de rapportage van de resultaten. De meeste studies hadden betrekking op een klein aantal PA's, maar vijf studies waren nationaal van opzet en beoordeelden de inzet van enkele honderden PA's en hun zorg voor duizenden patiënten. In 34 studies werd de PA ingezet ter vervanging van de traditionele artsenzorg en in vijf studies werd de PA ingezet in een additionele rol. De kwaliteit van de door een PA geleverde zorg was in 15 studies vergelijkbaar met die van een arts en in 18 studies was de kwaliteit van de zorg beter dan die van een arts. In totaal toonden 29 studies aan dat zowel de directe personele kosten (loonkosten) als de kosten van hulpmiddelen lager waren wanneer de PA de zorg verleende dan wanneer de arts de zorg verleende. De belangrijkste bevindingen waren dat PA's dezelfde of betere zorgresultaten leverden als artsen met dezelfde of lagere zorgkosten. Soms was deze efficiëntie te danken aan hun lagere loonkosten en soms omdat zij doeltreffender waren als producenten van zorg en activiteiten.

## Hoofdstuk 3

### Een activiteitenanalyse van Physician Assistants en Verpleegkundig Specialisten in ziekenhuizen

Hoofdstuk 3 presenteert de resultaten van een beschrijvende, niet-experimentele onderzoeksmethode voor het verzamelen en analyseren van kwantitatieve en kwalitatieve gegevens over de soorten taken die door een PA of VS in een ziekenhuissetting in Nederland worden uitgevoerd. Vijftien medische afdelingen in vier ziekenhuizen namen deel. Twee systemen werden onderzocht om de grote verscheidenheid aan klinische taken en rollen van PA's en VS-en te karakteriseren. Deze systemen waren het systeem voor de patiënten planning en het ziekenhuisinformatiesysteem. In totaal zijn 108 interviews afgenomen ter verificatie van de geïnventariseerde takenpakketten. Alle taken werden verdeeld in directe en indirecte patiëntenzorg. Zodra de taken waren gecatalogiseerd, werden door artsen en ziekenhuismanagers de door de PA of VS uitgevoerde taken beoordeeld op de bijdrage aan de productie van het ziekenhuis. In totaal werden 2883 taken geëvalueerd. Over het geheel genomen voerden PA's en VS-en een grote verscheidenheid aan klinische en administratieve taken uit, die verschilden per ziekenhuis en medisch specialisme. Uit de gegevens van de interviews en de ziekenhuisinformatiesystemen bleek dat meer dan een derde van de taken niet correct geregistreerd of aan de PA of VS toegewezen was. Deze administratieve tekortkoming kwam aan het licht als een systematisch

probleem en waren geen afspiegeling van de prestaties van de PA of de VS. Wel werd vastgesteld dat de VS en de PA meer dan twee-derde van hun werktijd besteedden aan directe patiëntenzorg. De consistentie van deze taken verschilde per medisch specialisme, maar hoewel een groot deel van de taken niet zichtbaar was door de manier waarop de gegevens werden verzameld, bleek uit de interviews met artsen en managers dat de inzet van een VS of PA werd beschouwd als een toegevoegde waarde voor zowel de kwaliteit van de zorg als voor de productie voor ziekenhuiszorg.

## Hoofdstuk 4

### Een kosteneffectiviteitsanalyse van physician assistants in de intramurale zorg

Hoofdstuk 4 presenteert het substitutie-effect van intramurale zorg van artsen naar PA's. Een multicenter quasi experimentele Matched Controlled Trial moest de kosteneffectiviteit onderzoeken binnen ziekenhuizen. Het traditionele model waarin alleen artsen verantwoordelijk waren voor de zorg voor patiënten opgenomen in een ziekenhuis werd vergeleken met een gemengd model waarin PA's worden ingezet (PA/arts-model). De studie betrof zorgverleners op 34 verschillende ziekenhuisafdelingen in heel Nederland. De deelnemers waren 2.292 patiënten en werden gevolgd vanaf opname tot een maand na ontslag. Patiënten die dagbehandeling kregen, terminaal zieke patiënten en kinderen werden uitgesloten. Primaire en secundaire uitkomstmaten en alle directe zorgkosten vanaf de dag van opname tot een maand na ontslag werden in kaart gebracht. Gezondheidsuitkomsten werden beoordeeld aan de hand van voor kwaliteit gecorrigeerde levensjaren (QALY's), zoals gemeten met de EuroQol-5D-vijfdimensionale vragenlijst. Het resultaat was dat er geen significant verschil naar voren kwam voor QALY-winst (+0,02, 95% CI -0,01 tot 0,05) bij vergelijking van het PA/ arts-model met het arts-model. De totale kosten per patiënt verschilden niet significant tussen de groepen.

Wat betreft de kosten per onderdeel werd een verschil van 309 euro per patiënt gevonden in het voordeel van het arts-model met betrekking tot de verblijfsduur. De personeelskosten per patiënt op basis van de zorgverlener die primair verantwoordelijk is voor de medische zorg op de afdeling waren lager op de afdelingen in het PA/arts-model. De conclusie was dat de kosteneffectiviteit van afdelingen gerund door PA's, in samenwerking met artsen vergelijkbaar was met de zorg op afdelingen met traditioneel artsen bezetting. De betrokkenheid van PA's kan de personeelskosten verlagen, maar niet de totale zorgkosten van één zorgepisode.

## Hoofdstuk 5

### De effecten van Physician Assistants en Verpleegkundig Specialisten op de huisartsenzorg in Nederland

Hoofdstuk 5 beschrijft de effecten van PA's en VS-en in de huisartsenzorg aan de hand van een mixed method onderzoek in vier representatieve praktijken op basis van jaarlijkse gegevens over patiëntencontacten, aangevuld met diverse interviews. In veel westerse landen spelen huisartsen een centrale rol in de zorgverlening. Nu de bevolking vergrijst en de zorg verschuift van het ziekenhuis naar de eerstelijnszorg, neemt de werklast van de huisarts toe. De tewerkstelling van PA's en VS-en helpt de vraag naar eerstelijnszorgdiensten te compenseren. Uit onderzoek is weliswaar gebleken dat de inzet van PA's en VS-en van invloed is op de kwaliteit van de zorg, maar er is weinig onderzoek gedaan naar de werkdruk en het rendement van de kosten. De inhoud en de effecten van hun tewerkstelling op de werklast voor huisartsen en het rendement van investeringen werden onderzocht in vier verschillende soorten huisartsenpraktijken met behulp van een mixed methods. Retrospectief onderzoek van huisartsenpraktijken waar een PA of NP in dienst was aangevuld met elektronische gegevens uit de praktijkinformatiesystemen werden gecombineerd met interviews met huisartsen, PA's, VS-en, praktijkondersteuners, eerstelijnsverpleegkundigen en praktijkmanagers. Daarnaast nam, om de generaliseerbaarheid te onderzoeken, een representatieve groep artsen uit 13 praktijken deel als referentiegroep om de bevindingen te bespreken en valideren. Het aantal ingeschreven patiënten van de vier praktijken varieerde van 2.600–9.900. De jaarlijkse productie van elke huisartsenpraktijk omvatte consulten, huisbezoeken, telefonische consulten en procedures. De factureerbare productie van de diensten bedroeg 69,6% tot 100%, met een gemiddelde van 71,4% voor de VS-en en 85% voor de PA's. Gemiddeld zagen de PA's een breed scala aan patiënten, terwijl de VS-en zich meer bezighielden met kwetsbare en oudere patiënten. In alle vier de gevallen van representatieve huisartsenpraktijken was de tewerkstelling van de PA of VS bevredigend; de werklast van de huisartsen werd tot op zekere hoogte verlicht en tijdens hun tewerkstelling werd aan de groeiende vraag naar zorg voldaan met een betere dienstverlening. Drie van de vier praktijken waren positief over het directe financiële rendement van hun werk. In het algemeen hadden de PA en de VS een positieve invloed op de vermindering van de werklast van de huisartsen.

# Curriculum Vitae

Geert van den Brink is geboren op 11 augustus 1959 in Oosterhout, nabij Nijmegen. Hij groeide op als vijfde kind in een gezin met zes kinderen. Zijn vader was fruitkweker in een gebied dat nu helemaal verstedelijkt is.

Na de middelbare school is Geert, net 18 jaar oud in 1977, de inservice opleiding tot verpleegkundige in het Sint Elisabeth Gasthuis in Arnhem gaan volgen. Hierna volgde hij de intensive care opleiding. In januari 1986 heeft hij het vak van verpleegkundige ingeruild voor docent in het St. Radboudziekenhuis en heeft hij verschillende lerarenopleidingen gevolgd. In 2001 behaalde Geert zijn Master of Science titel binnen Gezondheidswetenschappen van de Universiteit Maastricht.

Geert heeft binnen het Radboudumc verschillende functies vervuld, o.a. directeur van de Radboudzorgacademie. Zijn werkzaamheden binnen het Radboudumc combineert hij sinds 1993 met zijn werk aan de Hogeschool van Arnhem en Nijmegen. Eerst binnen het Transferpunt Vaardigheidsonderwijs, de lerarenopleiding en vanaf 2002 heeft hij de masteropleiding Physician Assistant (MPA) opgezet waar hij nog steeds de opleidingscoördinator van is.

Geert is sinds 2004 voorzitter van het Landelijk Platform Verpleegkundig Specialisten en Physician Assistants en sinds 2008 is hij ook voorzitter van het Landelijk Platform Bachelor Medische Hulpverlening. (BMH). In die hoedanigheid heeft Geert een nauwe betrokkenheid gehad bij de wet BIG-trajecten en registratie van deze beroepsgroepen.

Tijdens het jubileumcongres ter gelegenheid van het 10-jarig bestaan van het beroep Physician Assistant heeft Geert een koninklijke onderscheiding mogen ontvangen als Ridder in de Orde van Oranje-Nassau voor zijn werk binnen de opleiding en beroep van PA alsmede zijn werk ten behoeve van de intensive care opleiding. Hij heeft diverse subsidies verworven voor onderzoek naar de positionering van de PA en de VS in Nederland. In 2018 heeft Geert een Comenius fellowship beurs verworven met als onderwerp ‘gelijke kansen binnen de opleiding PA’.

Momenteel is Geert, naast zijn coördinatie van de master PA binnen de HAN, werkzaam voor de academische opleidingen van het Radboudumc op het gebied van Diversiteit, Inclusie en Equity.

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# PhD Portfolio

Name PhD candidate: GTWJ van den Brink
PhD period: 31-10-2016 until 01-05-2023
Promotor(s): prof. dr. H. Vermeulen
Co-promotor(s): dr. M.G.H. Laurant

| Training activities | Year | EC Points |
|---|---|---|
| Graduate School specific introductory course | 2018 | 1.00 |
| Brok Course (no certificate) | 2014 | 2.00 |
| Opfriscursus Pubmed | 2017 | 0.25 |
| Cursus Kwalitatief Onderzoek | 2016 | 1.00 |
| Kenniskring Lectoraat | 2016-19 | 3.00 |
| PAEA Conference Denver USA | 2017 | 2.00 |
| Masterclass Capaciteitsplanning in de zorg | 2018 | 1.00 |
| Academic Writing | 2017-18 | 2.30 |
| Physician Associates in the Care Workforce: designing a research agenda for the coming decade (Queen Mary University London) | 2018 | 0.80 |
| Program for the PA accreditation board (NCCPA) | 2018 | 0.80 |
| Exchange PA program University of Utah (Salt Lake City) | 2018 | 2.00 |
| Symposium Hartchirurgie Radboudumc | 2018 | 0.25 |
| Conference Future Health (Zurich) | 2019 | 1.00 |
| Exchange PA and NP in Birgmingham | 2019 | 2.00 |
| Exchange PA program University of Utah (Salt Lake City) | 2019 | 3.00 |
| Online course update Pubmed | 2020 | 0.50 |
| Congres NVMO | 2022 | 0.50 |
| PAEA Conference San Diego USA | 2022 | 1.00 |
| | **Subtotal** | **25.10** |

| Teaching Activities | Year | EC Points |
|---|---|---|
| Working Group MPA students (monthly) | 2016-2023 | 120.00 |
| Presentation MPA program | 2017 | 0.30 |
| Presentation University of Utah | 2018 | 0.50 |
| Presentation Queen Mary University London | 2018 | 0.50 |
| Presentation MANP program | 2018 | 0.25 |
| Presentation NP and PA InHolland | 2019 | 0.25 |
| Presentation Salt Lake City | 2019 | 0.75 |
| Thesis MPA students | 2019-20 | 30.00 |
| | **Subtotal** | **152.55** |
| **TOTAL** | | **178** |

# Datamanagement

## Beveiligde data opslag

Bij het opslaan en gebruik van data zijn de richtlijnen gevolgd zoals vastgelegd in het Datamanagementplan van de HAN University of Applied Sciences (versie 1.0, 2016). Deze richtlijnen zijn gebaseerd op de Gedragscode Praktijkgericht Onderzoek (Vereniging Hogescholen). Tevens zijn in dit onderzoek de volgende richtlijnen gevolgd:

- Richtsnoeren informatiebeveiliging van het Autoriteit Persoonsgegevens (AP),
- Wet bescherming persoonsgegevens (Wbp/ Algemene Verordening Gegevens bescherming (AVG),
- Integriteitcode (HAN),
- Gedragscode voor onderzoek met mensen (HAN)

## Eigenaarschap data

De data zijn eigendom van de HAN. Alle originele gegevens als ook bestanden voor analyse en meetinstrumenten zijn opgeslagen op de R-schijf/ AGV/master PA onder een speciale map promotie onderzoek Geert van den Brink. Deze map is alleen toegankelijk voor de promovendus en co-promotor en data zijn geanonimiseerd opgeslagen. Alle naar persoon of organisatie herleidbare data zijn verwijderd.

## Data management

Na afronding van de laatste publicatie blijft alle data opgeslagen op de bovengenoemde map op de R-schijf. Alle opgeslagen gegevens worden voor een periode van 10 jaar bewaard.

Dr. M.G.H. Laurant is projectleider en G. van den Brink worden na 10 jaar geïnformeerd door onderzoek ondersteuning/archivaris van de HAN over afloop van de bewaartermijn. Zij nemen dan een besluit of de data kan worden vernietigd of indien gewenst, de data voor langere periode beschikbaar moet blijven (bewaartermijn wordt dan opnieuw vastgesteld) dan wel via openbare databases (bv.DANS Easy) wordt aangeboden. HAN is verantwoordelijk voor dagelijkse back-up van de files, R-schijf.

# Dankwoord

Met dit dankwoord komt er dan toch echt een einde aan het schrijven van dit proefschrift. Daarmee wordt ook een periode afgesloten waarin ik een deel van de week bezig was met 'het doen van onderzoek' naast mijn werkzaamheden voor de PA-opleiding en de landelijke platformen (Platform BMH en platform VS en PA).

Ik voel mij bevoorrecht dat ik de mogelijkheid heb gekregen om de effecten van de inzet van de Verpleegkundig Specialist en Physician Assistant op een wetenschappelijke wijze onder de aandacht te brengen, het was, overall, een mooie tijd. Een tijd waarin ik veel heb geleerd. Zoals vaak bij leren het geval is gaat dat gepaard met (constructieve) fricties, zo was dat ook bij mij het geval. Ik heb veel geleerd over wetenschap en hoe beleidsmatige onderzoeken en evaluatie zich verhouden tot wetenschappelijke onderzoeken. Ook heb ik geleerd dat een objectieve en open mind belangrijk is.

Het gezegde 'you can't teach an old dog new tricks' heb ik in mijn geval voor een groot deel kunnen verwerpen.

Mijn ervaring is dat mijn promotoren, **Hester** en **Miranda** hun begeleiding hebben aangepast met waarschijnlijk dat gezegde in hun achterhoofd.

Daarnaast veel dank aan Miranda: wat ben je toch precies en nauwgezet (en drukbezet). Jouw uitgebreide feedback, gelukkig zonder veel omhalen, was altijd to-the-point en tot steun. Ook de verschillende discussies hebben we steeds inhoudelijk kunnen voeren met het uitgangspunt van wederzijds respect. Jouw kennis van dit gebied in combinatie met je wetenschappelijke ervaring is een geweldige steun voor mij geweest, wanneer Miranda tevreden is dan moet het wel goed zijn...

Hester, bij de start van mijn promotie was je onbekend bij mij. Jouw begeleiding kenmerkte zich van een aanpak die recht deed aan mijn ervaring en positie. Je hebt mij geleerd dat beleidsmatig gedreven onderzoek niet zomaar om te zetten is naar wetenschappelijk onderzoek. Daarnaast

waardeer ik je pleidooi voor de positie van de verpleegkundige beroepsgroep en in het bijzonder die van de verpleegkundig specialist.

Mijn buddy **Rod Hooker** ben ik veel dank verschuldigd. In onze tweewekelijkse onlinegesprekken, voor Rod in de ochtend en voor mij in de avond, waarbij pragmatiek aangevuld met heel veel kennis van economisch onderzoek naar de inzet van PA's denk ik met plezier terug, zonder de steun van Rod was dit me niet gelukt.

*To my buddy Rod Hooker: I owe you many thanks. In our bi-weekly online conversations, for Rod in the morning and for me in the evening, where pragmatism complemented by knowledge of economic research on the use of PAs. I keep fond memories, without your support I would not have succeeded.*

De vierde belangrijke persoon voor mij bij het verwezenlijken van mijn proefschrift is **Arjan Kouwen**. De onderzoeken en evaluaties naar de effecten van de VS en PA die we samen zijn aangegaan onder de vlag van het Platform VS-PA zijn de basis geweest voor twee hoofdstukken van dit proefschrift.

Daarvoor gaat ook de dank uit naar **Tom Hoogeveen**, als senior beleidsambtenaar en vriend hebben we veel gesproken en gedaan om de taakherschikking verder te brengen. Gelukkig heb ik je vriendenclub BAS nooit hoeven in te roepen...

Ik wil tevens graag de leescommissie bedanken voor de moeite die ze hebben genomen om dit proefschrift door te lezen en te beoordelen.

Dank ook aan 'mijn' **PA opleidingsteam**, voor alle belangstelling en steun en nu mag ik pas echt meedoen met de wetenschapsdocenten...

Als promovendus word je geacht een mentor te hebben, ik ben blij dat **Andre van der Ven** die rol heeft willen oppakken.

**Guido Athmer**, hartelijk dank voor de opmaak en begeleiding bij het drukken.

Ook dank naar mijn werkgever, de Radboud Health Academie in de persoon van **Roland Laan** dat ik de kans en de ruimte heb gekregen om deze promotie te kunnen doen.

Last but not least wil ik mijn thuisfront bedanken voor de ruimte die ik kreeg om de vele avonden en de verschillende dagen in de vakanties achter mijn computer door te brengen. Jullie zijn mijn basis, onze vier, verschillende zonen, vier is echt een magisch getal, **Sem, Daan, Luuk en Max** en natuurlijk **Anneke**, zonder jou is er niets.

Tot slot wil ik een gezegde van Gandhi aanhalen:

"Live as if you were to die tomorrow.
Learn as if you were to live forever."

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