Physician assistants in medical ward care: a descriptive study of the situation in the Netherlands

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Abstract

Rationale, aims and objectives Medical ward care has been increasingly reallocated from medical doctors (MDs) to physician assistants (PAs). Insight into their roles and tasks is limited. This study aims to provide insight into different organizational models of medical ward care, focusing on the position, tasks and responsibilities of the involved PAs and MDs. **Methods** In this cross-sectional descriptive study 34 hospital wards were included. Characteristics of the organizational models were collected from the heads of departments. We documented provider continuity by examination of work schedules. MDs and PAs in charge for medical ward care ($n = 179$) were asked to complete a questionnaire to measure workload, supervision and tasks performed. **Results** We distinguished four different organizational models for ward care: medical specialists in charge of admitted patients (100% MS), medical residents in charge (100% MR), PAs in charge (100% PA), both MRs and PAs in charge (mixed PA/MR). The wards with PAs had the highest provider continuity. PAs spend relatively more time on direct patient care; MDs spend relatively more time on indirect patient care. PAs spend more hours on quality projects ($P = 0.000$), while MDs spend more time on scientific research ($P = 0.030$). **Conclusion** Across different organizational models for medical ward care, we found variations in time per task, time per bed and provider continuity. Further research should focus on the impact of these differences on outcomes and efficiency of medical ward care.

Introduction

Background

In recent years, hospital care is characterized by increasing demands for efficiency in health care, a rising prevalence of chronic diseases, ongoing specialization in medical disciplines and increasing dependence on new technologies [1]. In light of these developments, many hospitals, particularly in the United States, have adopted the hospitalist model as one of the primary methods to cope with these challenges [2,3]. Hospitalists are responsible for the delivery and coordination of the general medical care of the hospitalized patients [4]. Their work includes daily ward rounds, performing physical examinations, making decisions regarding necessary tests, treatments and procedures, render medical diagnoses and generating and reviewing clinical data [3]. In the Netherlands, medical care on hospital wards is mostly provided by medical residents (MRs). These residents cover medical care for the admitted patients at a specific hospital department and are being supervised by medical specialists (MSs) who are easily accessible.

Because of a growing need for cost-effective delivery and a local shortage of MRs, as well as concerns about the quality and

safety of clinical processes, in for example the United States, Canada, England and the Netherlands medical ward care has been increasingly reallocated to physician assistants (PAs) [5–7]. A PA is a non-physician health care professional licensed to practice medicine in defined domains, with variable degrees of professional autonomy [8]. The PA profession in the Netherlands has been in existence since 2001 and has been described previously [9]. In short, Dutch PA students are professionals with a health care-related bachelor's degree and at least 2 years of clinical work experience in the health care domain. After that, they follow a 30-month training programme at a master's degree level. Different from other countries, the Dutch PA programmes incorporate a dual work–education model, which means that students are employed within a particular medical specialty from the day of their enrolment in the master's PA programme. The students undertake didactic and clinical education within this medical specialty from the beginning until the end of the curriculum [10,11]. PAs conduct low to moderately complex medical tasks within a certain specialty, both in primary and secondary care. In the Netherlands, most of them practice in the hospital setting. Since January 2013, PAs are authorized to indicate and perform predefined medical procedures and subscribe medication without supervision.

As new as hospitalists are, PAs providing medical care at hospital wards is an even newer concept and the specific roles and responsibilities widely vary. Often, PAs who are employed for medical ward care work in a system of collaborative care that contains both PAs and medical doctors (MDs), comprising a patient medical care team. Several American studies have examined the safety and quality of care provided by PAs. These studies indicate that PAs provide care of quality and efficiency similar to that of traditional house staff services [12–17]. These studies lack, however, a clear description of the tasks and responsibilities of PAs and MDs working on the hospital ward. Insight in their roles and division of work is relevant for the interpretation of the findings and helps to develop safe and efficient models of inpatient care.

Study aim

This descriptive study aims to provide insight into different organizational models of medical ward care, focusing on the position, tasks and responsibilities of PAs and MDs who provide medical care at wards in Dutch hospitals.

Methods

Study design

This cross-sectional descriptive study was conducted as part of a prospective multicentre study on the effectiveness of substitution of medical ward care from MDs to PAs, which was based in the Netherlands. The study design has been described in detail previously [9]. In short, a non-randomized matched-controlled study was performed, comparing 17 wards on which PAs provide medical care contingent with MDs (intervention group) with 17 wards on which only MDs provide medical care (control group). MDs include MSs and MRs. Control wards were matched with the intervention wards on the basis of medical specialty (i.e. surgery, pulmonology, cardiology, internal medicine, gastroenterology, etc.) and hospital type (i.e. academic vs. non-academic).

Study population

For the purpose of this descriptive study, all participating hospital wards, both intervention and control wards, were included ($n = 34$). We included all MSs (staff physicians), MRs and PAs who provided medical care on these wards in the previous year ($n = 179$).

Study measures

Measures related to hospital wards

After analysis of the first eight recruited hospital wards, we distinguished four different organizational models of medical care: (1) MSs are in charge of all admitted patients (100% MS); (2) MRs or junior doctors are in charge of all admitted patients, with supervision of MS (100% MR); (3) PAs are in charge of all admitted patients, with supervision of MS (100% PA); and (4) both MRs as PAs are in charge of the admitted patients, with supervision of MS (mixed PA/MR). Because in the Netherlands the major part of the medical care on the hospital ward happens at daytime on weekdays, the percentages of these organizational models were based only on the staffing during daytime (8AM–6PM) on weekdays, irrespective of who staffs the ward in case of emergency during evenings, nights and weekends. The classification remained unchanged after the recruitment of the other 26 hospital wards.

Characteristics of the organizational models were collected by an online questionnaire that was administered at the start of the study by the heads of departments. In case of a mixed PA/MR team, we asked whether MRs and PAs care for similar patient groups or whether a non-random *allocation of patients* was made per profession. We documented *provider continuity* by examination of work schedules. All MDs and PAs who were employed for ward care 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, during daytime on weekdays. We assessed provider continuity by counting the number of different medical care providers during these 4 weeks. Besides, we assessed continuity by calculating the percentage of the total hours which were spend for medical ward care by the most attending MD or PA. In case of a mixed PA/MR model, we additionally derived the *PA/MR ratio* from the work schedules. The PA/MR ratio was defined as the percentage of all ward care hours that was fulfilled by PAs during the four fixed weeks.

Measures related to MDs and PAs

An online questionnaire was compiled and used to measure three job characteristics: workload, supervision and tasks performed. *Workload* was measured in terms of the number of beds per week and weekly overtime hours. We also asked how many hours of *supervision* was obtained per week. Besides, we asked for the *extent of the employment* by asking for the number of hours their work week contains usually. A work week of less than 36 h was defined as a part-time job extent. We also asked for the *irregularity of employment*. For that, we asked whether the care provider works during day shifts, night shifts or weekend shifts, or a combination of these. Subsequently, we asked for the number of hours per week spent on different tasks, divided into five categories: (1) *direct*

patient care on the ward, for example, doing ward rounds, obtaining medical history, performing physical examinations and conversations with patients relatives; (2) *indirect patient care on the ward*, for example, reporting in medical patient records, requesting additional tests, writing patient handovers and patient-related interdisciplinary or multidisciplinary conversations; (3) *medical procedures which are not performed at the hospital ward*, like surgical procedures and performing endoscopies; (4) *outpatient contact*; and (5) *non-patient-related tasks*. These non-patient-related tasks were divided into five subcategories: participating in quality and patient safety projects, providing education (e.g. supervising medical interns, providing training for nursing or medical staff), performing scientific research and professional development (i.e. going to conferences, reading articles or textbooks). Besides, the *demographic variables* gender, age, profession, years since graduation and years working on the hospital ward were collected.

Measures related to patients

To provide insight into the characteristics of patients who are involved in the different organizational models, we collected data about gender, age, ethnicity, education level, marital status and co-morbidity index. These variables were retrospectively derived from medical records from all patients who were recruited for the prospective multicentre study. To assess the level of co-morbidities, we used the Charlson index, which is a weighted estimate for co-morbidity and takes into account both the number and seriousness of co-morbid diseases [18].

Data analyses

Descriptive statistics were used to present the quantitative data. Medians and interquartile ranges (IQR) were used for continuous variables, and proportion (%) for categorical variables. Outcomes related to wards and medical care providers are presented for the four different organizational models; that is, 100% MS, 100% MR, 100% PA, mixed PA/MR. Differences between the organizational models were examined using one-way ANOVA for normally distributed continuous variables. Kruskal–Wallis one-way analysis of variance was used for non-normally distributed continuous variables. Pearson's chi-squared test was used for categorical variables. Statistical significance was set at $P < 0.05$. All analyses were performed with the SPSS software package version 20.0 for Windows.

Results

Hospital wards

Thirty-four hospital wards were included, which were spread over 23 hospitals across the country. All heads of the departments returned the online questionnaire measuring the characteristics of the hospital wards. No answers were missing on the relevant questions. Four different models for medical ward care were distinguished. At four wards solely MS was responsible for inpatient care. At 13 wards only MRs provided medical care (100% MR). At five wards only PAs were employed for medical care (100% PA) and at 12 wards both PAs and MRs were employed (mixed PA/MR). In the mixed PA/MR models, median 68% (IQR 48–77) of the ward care hours were fulfilled by PAs. The characteristics per type of organizational model are described in Table 1. In both the 100% PA group as in the 100% MS group, only non-teaching centres are represented. The 100% MR group and the mixed PA/MR group consist predominantly of teaching centres. The number of beds only slightly differs between the different models.

The patient population differs significantly among the organizational models with regard to the demographic characteristic gender, age, ethnicity, education level and marital status (Table 2). There is no difference with regard to their co-morbidity. About 40% of the patients in each organizational model had more than one co-morbid diagnosis according to the Charlson index.

All PAs and MRs who collaborate in a team on a ward with a mixed PA/MR model randomly divide the patients among them. No selection was applied based on, for example, diagnoses or complexity. The wards with the 100% PA model had the least

Table 1 Characteristics of hospital wards (*n* = 34) presented by four organizational models for medical ward care

	100% MS (*n* = 4)	100% MR (*n* = 13)	Mixed PA/MR (*n* = 12)	100% PA (*n* = 5)
Teaching status				
Teaching *n (%)*	0 (0%)	9 (69%)	10 (83%)	0 (0%)
Non-teaching *n (%)*	4 (100%)	4 (31%)	2 (17%)	5 (100%)
Medical specialty				
Cardiology *n (%)*	1 (25%)	0 (0%)	1 (8%)	0 (0%)
Gastroenterology *n (%)*	0 (0%)	2 (15%)	2 (17%)	0 (0%)
Head and neck surgical oncology *n (%)*	0 (0%)	1 (8%)	1 (8%)	0 (0%)
Orthopaedics *n (%)*	1 (25%)	0 (0%)	0 (0%)	1 (20%)
Pulmonology *n (%)*	1 (25%)	1 (8%)	2 (17%)	0 (0%)
Surgery *n (%)*	1 (25%)	9 (69%)	6 (50%)	4 (80%)
Number of beds *median (IQR)*	25.5 (17.8–29.5)	27.0 (18.3–38.0)	22.0 (20.5–34.5)	30.0 (21.0–31.5)
Number of different ward care providers *median (IQR)*	5 (4–6)	4 (3–6)	4 (3–5)	1 (1–2)
% of total hours medical ward care by most attending provider *median (IQR)*	38 (32–45)	43 (34–52)	65 (44–74)	100 (100–100)

IQR, interquartile range; MR, medical resident; MS, medical specialist; PA, physician assistant.

Table 2 Characteristics of patients presented by four organizational models for medical ward care

	100% MS (*n* = 346)	100% MR (*n* = 917)	Mixed PA/MR (*n* = 689)	100% PA (*n* = 309)	*P*-value
Gender, male *n (%)*	173 (50%)	495 (54%)	372 (54%)	139 (45%)	0.015
Age, years *(mean ± SD)*	65 ± 12	61 ± 16	63 ± 16	64 ± 16	0.000
Ethnicity, Dutch *n (%)*	333 (94%)	894 (95%)	680 (96%)	302 (96%)	0.028
Highest education					0.002
Low *n (%)*	133 (39%)	293 (32%)	255 (37%)	117 (39%)	
Middle *n (%)*	135 (40%)	361 (39%)	281 (41%)	101 (33%)	
High *n (%)*	71 (21%)	262 (29%)	150 (22%)	88 (28%)	
Marital status					0.048
No partner *n (%)*	26 (8%)	147 (16%)	99 (15%)	40 (13%)	
Partner *n (%)*	274 (80%)	685 (75%)	500 (73%)	233 (76%)	
Widow *n (%)*	40 (12%)	85 (9%)	84 (12%)	35 (11%)	
Charlson index for co-morbidity *score* ≥1 *n (%)*	131 (37%)	396 (42%)	300 (42%)	117 (37%)	0.060

MR, medical resident; MS, medical specialist; PA, physician assistant; SD, standard deviation.

Table 3 Characteristics of PAs and MDs employed for medical ward care (*n* = 130), presented by four organizational models for ward care

	100% MS (*n* = 19)	100% MR (*n* = 71)	Mixed PA/MR (*n* = 34)		100% PA (*n* = 6)	*P*-value
			PA (*n* = 17)	MR (*n* = 17)		
Age, years *median (IQR)*	44 (40–53)	27 (26–30)	37 (33–43)	28 (27–31)	42 (29–49)	0.000
Gender, male *n (%)*	16 (84)	35 (49)	3 (18)	8 (47)	1 (17)	0.001
Years since graduation *median (IQR)*	7 (3–15)	1 (1–3)	2 (1.5–3)	1 (0–4)	4 (1–6)	0.000
Irregularity of work						
Dayshifts *n (%)*	19 (100)	71 (100)	17 (100)	17 (100)	6 (100)	0.916
Night shifts *n (%)*	18 (95)	49 (69)	0 (0)	12 (71)	0 (0)	0.000
Weekend shifts *n (%)*	18 (95)	61 (86)	0 (0)	12 (71)	0 (0)	0.000
Job extent, part time* *n (%)*	0 (0)	2 (3)	1 (6)	1 (6)	2 (33)	0.016
In charge for number of beds *median (IQR)*	12 (8–24)	16 (14–20)	17 (11–21)	15 (12.5–20)	22 (19–30)	0.049
Hours per week . . .						
Working in the hospital, incl overtime *median (IQR)*	60 (50–60)	53 (48–60)	43 (40–44)	53 (47–57)	37 (29–40)	0.000
Overtime *median (IQR)*	NA	11 (7.8–20.5)	5 (4–8)	10 (7–14)	3 (2–5)	0.000
Time medical ward care *median (IQR)*	15 (3–30)	33 (24–48)	36 (32–43)	38 (19–45)	28 (22–32)	0.001
Time medical ward care per bed *median (IQR)*	1.0 (0.3–1.7)	1.6 (1.2–2.9)	2.3 (1.9–3.4)	2.0 (1.2–3.0)	1.3 (1.1–1.4)	0.000
Time received supervision *median (IQR)*	1 (0–2)	3 (2–5)	5 (4–6)	2 (1–5)	2 (1–2)	0.002

*Part time was defined as a working week less than 36 h.

IQR, interquartile range; MD, medical doctor; MR, medical resident; MS, medical specialist; NA, not applicable; PA, physician assistant.

number of different medical care providers (median 1, IQR 1–1.5), the wards with the 100% MS model had the highest (median 5, IQR 4.25–5.75). The percentage of the total hours which were spend for ward care by the most attending medical care provider was also highest at the wards with the 100% PA model (median 100%), followed by the wards with the mixed PA/MR model (median 65%).

Measures related to PAs and MDs

Of the 179 MDs and PAs who were invited to fulfil the questionnaire, a total of 130 completed questionnaires were returned (response rate 73%). The maximum item non-response was 4%. The features of different groups are presented in Table 3. Of all the professions, the MSs are the oldest and have the longest work experience, followed by the PAs. In contrast to the MSs and MRs,

none of the PAs worked on nightshifts and weekend shifts. The fewest hours per bed was with the providers from the 100% MS group and the 100% PA group; respectively median 1.0 h per week per bed versus 1.3 h per week per bed. In the mixed PA/MR models, the PAs spend median about double hours per week per bed (median 2.3). PAs from the 100% PA models receive the least supervision time in comparison to the PAs and MRs from the other organizational models (*P* = 0.002).

Besides job characteristics, we also measured the tasks performed (Fig. 1). The ratio between direct and indirect patient care on the hospital ward seems to differ between different organizational models. The MS from the 100% MS model and the PAs from the mixed PA/MR model spend similar amount of time on direct as on indirect patient care, while PAs from the 100% PA models spend relatively more time on direct patient care. In contrast, both MRs from the 100% MR models as the MRs from the
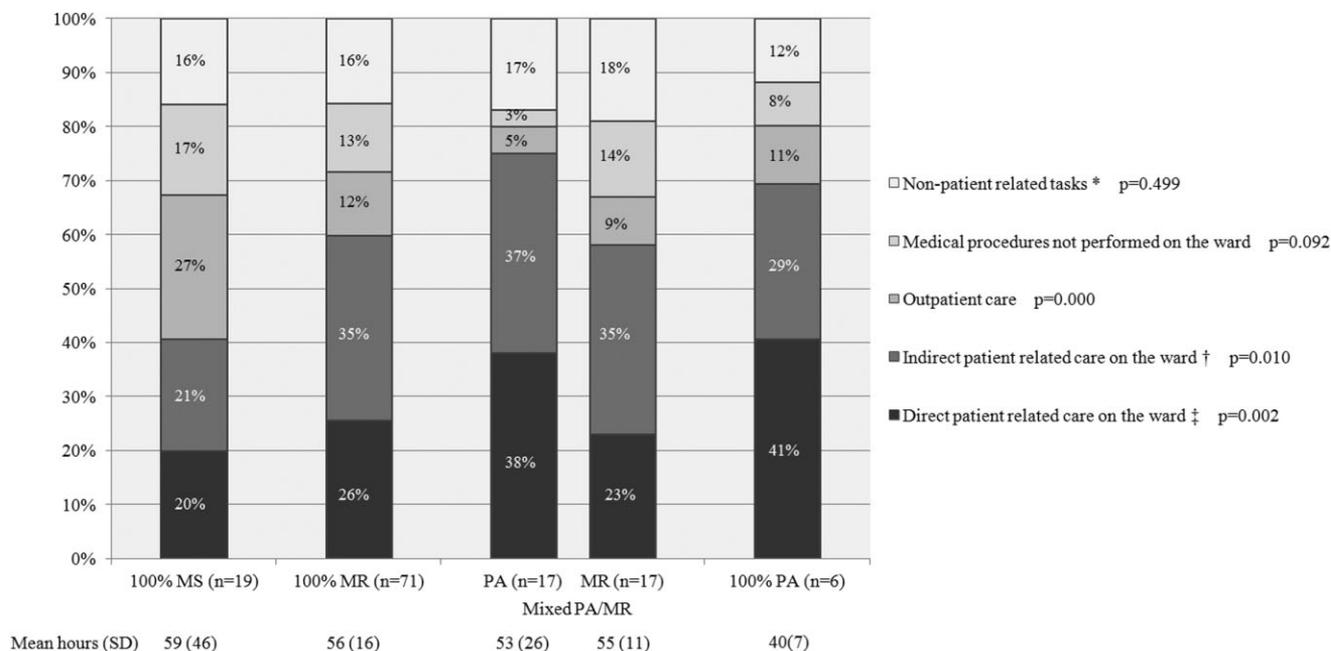
Figure 1 Proportion of tasks of PAs and MDs employed for medical ward care, presented by four organizational models for ward care. *P*-values represent the differences among the organizational models with respect to tasks performed.
MS, medical specialist; MR, medical resident; PA, physician assistant.
*Participating in quality and patient safety projects, providing education, performing scientific research, professional development.
†For example, surgical procedures and endoscopies.
‡For example, reporting in medical patient records, requesting additional tests, writing patient handovers and patient-related interdisciplinary or multidisciplinary conversations.
§For example, doing ward rounds, obtaining medical history, performing physical examinations and conversations with patients relatives

mixed PA/MR models spent more time on indirect patient care than on direct patient care. The tasks of the PAs and MRs who collaborate in the mixed PA/MR model differ slightly from each other. PAs spend relatively more time on direct inpatient care ($P = 0.020$), while the collaborating MRs spend relatively more time on tasks which are not performed at the hospital ward, like outpatient contacts ($P = 0.000$). The total time spend on non-patient-related tasks is relatively highest for the 100% MR and mixed PA/MR models. Looking at the specific tasks (Fig. 2), PAs in the mixed model seem to spend more hours on quality projects ($P = 0.000$), while MRs spend more time on scientific research ($P = 0.030$).

Discussion

In the present study, we aimed to provide insight into different organizational models of medical ward care, focusing on the position, tasks and responsibilities of attending PAs and MDs. We distinguished four different models, of which the 100% MR and the mixed PA/MR model were the most common in this study. The relatively high number of MRs who are employed for medical ward care is representative for hospital care in the Netherlands, but differs from the situation in some other countries. Although in the Netherlands medical care at hospital wards is mostly provided by MRs in order to gain medical experience, in the United States that position is mostly fulfilled by physicians who are specialized in hospital medicine (hospitalists) [3,19]. This perspective might be changing as hospital medicine is a new specialization in the Neth-

erlands. Currently, it is, however, unknown how these professionals will relate to other professionals who are involved in medical care at hospital wards.

Previous research of Van Vught *et al.* (2014) and Moote *et al.* (2011) showed that an important reason to employ a PA is to increase continuity [20,21]. Our study may suggest that provider continuity is indeed higher on the wards with the 100% PA model and the mixed PA/MR model than on the wards without PAs. In the literature, we did not identify similar analysis of medical ward care. Our results about provider continuity are in line with qualitative studies showing that physicians believe that their PA had improved continuity [21–23]. An increased provider continuity has been previously associated with improved patient outcomes and satisfaction [24]. Whether this is also the case on hospital wards in the Netherlands has yet to be investigated. Besides, we only measured continuity from the ward team perspective. We do not have information about the continuity of care from the patients' perspective, that is, the number of different professionals who are in charge for one patient. The better provider continuity might be related to the study result that PAs work only in daycare, while MDs also work on nightshifts and weekend shifts. This finding is in contrast with findings from an American study on the role of advanced practice providers in 123 inpatient medicine services, showing that about 32% of all PAs works on weekend shifts and about 18% works on night shifts [25].

Our data showed that PAs and MRs in the mixed PA/MR model spend the most time per bed in comparison with the other models.
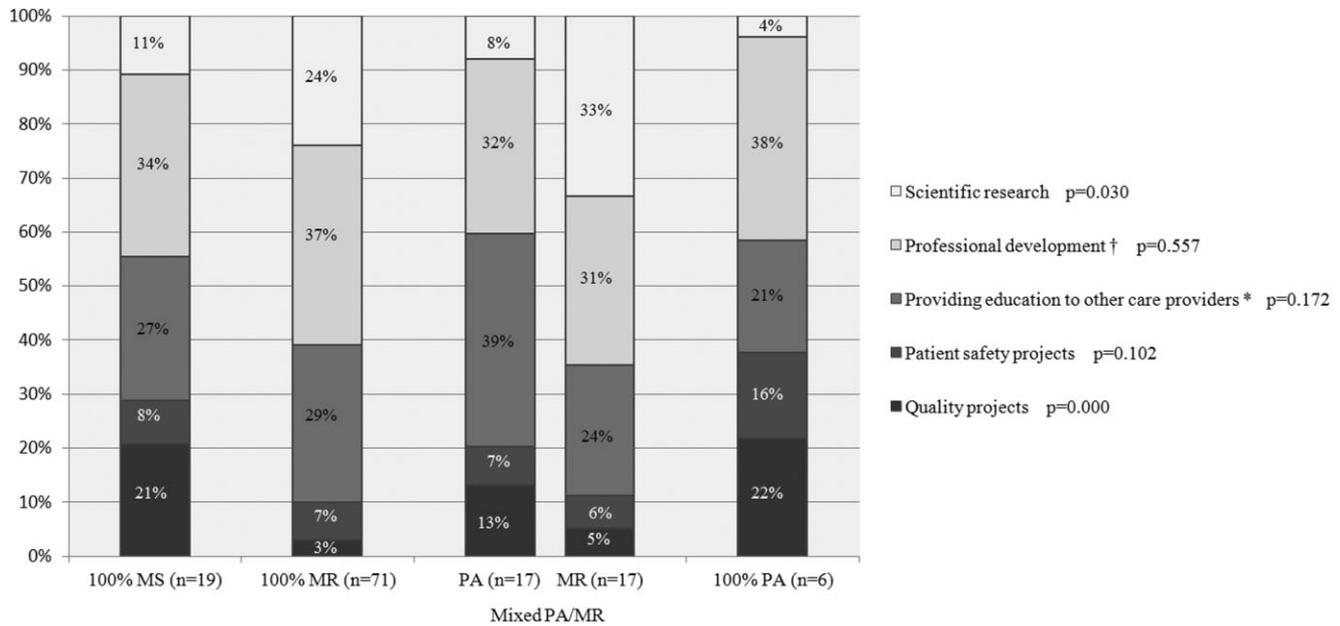
Figure 2 Specification of the proportion of non-patient-related tasks of PAs and MDs presented by four organizational models for ward care. *P*-values represent the differences among the organizational models with respect to tasks performed. MS, medical specialist; MR, medical resident; PA, physician assistant.
*For example, supervising medical interns, providing training for nursing or medical staff.
†For example, going to conferences, reading articles or textbooks.

This might indicate inefficiency because of the division of tasks and responsibilities, and the need for coordination between the PA and MR. This can increase costs, but can on the other hand improve quality of care and patient satisfaction. Further research is needed to investigate the implications of the time spend per bed for effectiveness and quality of care. Besides the number of hours spent per bed, also the received supervision time is higher for PAs in the mixed PA/MR model than for PAs in the 100% PA model. We do not have information about the causes of this difference. An explanation might be the fact that the PAs in the 100% PA model have more work experience than the PAs in the mixed model. Another explanation might be the teaching culture of the wards with the mixed PA/MD model. Because 83% of all included wards with a mixed model are from teaching centres while none of the wards with the 100% PA model are, there might be more consultation between workers and more emphasize on education. Further research should focus on the causes of the differences in supervision time, as well as on the consequences for effectiveness and safety of inpatient care.

Data about the tasks of the care providers showed differences in the proportion of time spend on direct and indirect patient care. PAs in both the 100% PA model as in the mixed PA/MR model spend relatively more time on direct patient care than on indirect patient care, while the MRs in the 100% MR model and the mixed PA/MR model spend relatively more time on indirect patient care than on direct patient care. A hypothesis is that, because PAs have median more years of work experience at the hospital ward, they are more familiar with the clinical protocols and the procedures to, for example, request diagnostic tests and consultation of other MS. As a consequence, they need less time for indirect patient care. Besides, as a consequence of the higher provider continuity, PAs

might be more familiar than MRs with the routines of other individual professionals, the medical team on the ward and multidisciplinary teams [26]. Also the fact that PAs have at least 2 years of clinical work experience in the health care domain before they enrol PA education might facilitate this. Further research should examine these hypotheses. Non-patient-related tasks of PAs and MRs differ slightly from each other. PAs seem to spend more hours on quality projects, while MRs spend more time on scientific research.

Some strengths and limitations can be mentioned. A strength of this study is the high response on the questionnaires, both from the heads of departments as from the PAs and MDs, which enhances the representativeness of our findings. Besides, we were able to include different organizational models from different types of hospitals across the country. We included 15 wards from teaching hospitals and 19 wards from non-teaching hospitals. This is approximately in proportion with the general situation in the Netherlands; 36 teaching hospitals and 60 nonteaching hospitals [27]. However, this cross-sectional study was part of a prospective study and the hospital wards were thus actively recruited for research purposes. Therefore, we cannot assure perfect representativeness for all hospital wards in the Netherlands. Another limitation of this study is the relatively small sample size, especially in the 100% PA model and the 100% MS model. For that, we presented medians with IQR instead of means with standard deviations. Results of the statistical analyses should however be interpreted with caution. Besides, the patient characteristics, except for the amount of co-morbidities, differed slightly among the models. Although differences were statistically significant, we have no indications that these small differences explain the variations in time per task and time per bed.

In conclusion, in this study we distinguished four different organizational models for medical ward care. Although the tasks are roughly the same between the models, the amount of time per task varies across the models and types of providers. Also the amount of time per bed and provider continuity varies across the models. Further research should focus on the consequences of these differences and the efficiency and effectiveness of the different organizational models.

Conflict of interest

Both M.J.C. Timmermans and A.J.A.H. van Vught work as a teacher at one of the PA master programmes. The other authors declare that they have no conflict of interest.

Authors contributions

MGHL and MJCT are responsible for the design of the study with comments of AJAHvV, MW and TW. MJCT is responsible for the data collection and data management with direct supervision and feedback from MGHL. MvdB, EDP, FR and JvU 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.

References

1. Salsberg, E. & Grover, A. (2006) Physician workforce shortages: implications and issues for academic health centers and policymakers. *Academic Medicine*, 81 (9), 782–787.
2. Wachter, R. M. & Goldman, L. (1996) The emerging role of 'hospitalists' in the American health care system. *The New England Journal of Medicine*, 335 (7), 514–517.
3. White, H. L. & Glazier, R. H. (2011) Do hospitalist physicians improve the quality of inpatient care delivery? A systematic review of process, efficiency and outcome measures. *BMC Medicine*, 9, 58, doi: 10.1186/1741-7015-9-58.
4. Society of Hospital Medicine. Available at: http://www.hospitalmedicine.org/Web/About_SHM/Hospitalist_Definition/About_SHM/Industry/Hospital_Medicine_Hospital_Definition.aspx (last accessed 17 August 2015).
5. Mittman, D. E., Cawley, J. F. & Fenn, W. H. (2002) Physician assistants in the United States. *British Medical Journal*, 325 (7362), 485–487.
6. Ford, W. T. & Britting, L. L. (2010) Nonphysician providers in the hospitalist model: a prescription for change and a warning about unintended side effects. *Journal of Hospital Medicine*, 5 (2), 99–102.
7. Hartsell, Z. (2007) The emerging role of PAs in the hospitalist movement. *Journal of the American Academy of Physician Assistants*, 20 (8), 10.
8. Merkle, F., Ritsema, T. S., Bauer, S. & Kuilman, L. (2011) The physician assistant: shifting the Paradigm of European medical practice? *HSR Proceedings in Intensive Care & Cardiovascular Anesthesia*, 3 (4), 255–262.
9. Timmermans, M. J., van Vught, A. J., Wensing, M. & Laurant, M. G. (2014) The effectiveness of substitution of hospital ward care from medical doctors to physician assistants: a study protocol. *BMC Health Services Research*, 14, 43, doi: 10.1186/1472-6963-14-43.
10. Spenkelink-Schut, G., Ten Cate, O. T. J. & Kort, H. S. M. (2008) Training the physician assistant in the Netherlands. *The Journal of Physician Assistant Education*, 19 (4), 46–53.
11. Hooker, R. S. & Kuilman, L. (2011) Physician assistant education: five countries. *The Journal of Physician Assistant Education*, 22 (1), 53–58.
12. Roy, C. L., Liang, C. L., Lund, M., Boyd, C., Katz, J. T., McKean, S. & Schnipper, J. L. (2008) Implementation of a physician assistant/hospitalist service in an academic medical center: impact on efficiency and patient outcomes. *Journal of Hospital Medicine*, 3 (5), 361–368.
13. Dhuper, S. & Choksi, S. (2009) Replacing an academic internal medicine residency program with a physician assistant–hospitalist model: a comparative analysis study. *American Journal of Medical Quality*, 24 (2), 132–139.
14. Miller, W., Riehl, E., Napier, M., Barber, K. & Dabideen, H. (1998) Use of physician assistants as surgery/trauma house staff at an American College of Surgeons-verified Level II trauma center. *The Journal of Trauma*, 44 (2), 372–376.
15. Oswanski, M. F., Sharma, O. P. & Raj, S. S. (2004) Comparative review of use of physician assistants in a level I trauma center. *The American Surgeon*, 70 (3), 272–279.
16. Gershengorn, H. B., Wunsch, H., Wahab, R., Leaf, D. E., Brodie, D., Li, G. & Factor, P. (2011) Impact of nonphysician staffing on outcomes in a medical ICU. *Chest*, 139 (6), 1347–1353.
17. Singh, S., Fletcher, K. E., Schapira, M. M., Conti, M., Tarima, S., Biblo, L. A. & Whittle, J. (2011) A comparison of outcomes of general

medical inpatient care provided by a hospitalist-physician assistant model vs a traditional resident-based model. *Journal of Hospital Medicine*, 6 (3), 122–130.

18. Charlson, M. E., Pompei, P., Ales, K. L. & MacKenzie, C. R. (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *Journal of Chronic Diseases*, 40 (5), 373–383.

19. Baudendistel, T. E. & Wachter, R. M. (2002) The evolution of the hospitalist movement in the USA. *Clinical Medicine*, 2 (4), 327–330.

20. Moote, M., Krsek, C., Kleinpell, R. & Todd, B. (2011) Physician assistant and nurse practitioner utilization in academic medical centers. *American Journal of Medical Quality*, 26 (6), 452–460.

21. van Vught, A. J., van den Brink, G. T. & Wobbes, T. (2014) Implementation of the physician assistant in Dutch health care organizations: primary motives and outcomes. *The Health Care Manager*, 33 (2), 149–153.

22. Taylor, M. T., Wayne Taylor, D., Burrows, K., Cunnington, J., Lombardi, A. & Liou, M. (2013) Qualitative study of employment of physician assistants by physicians: benefits and barriers in the Ontario health care system. *Canadian Family Physician*, 59 (11), e507–e513.

23. White, H. & Round, J. E. (2013) Introducing physician assistants into an intensive care unit: process, problems, impact and recommendations. *Clinical Medicine*, 13 (1), 15–18.

24. van Walraven, C., Oake, N., Jennings, A. & Forster, A. J. (2010) The association between continuity of care and outcomes: a systematic and critical review. *Journal of Evaluation in Clinical Practice*, 16 (5), 947–956.

25. Kartha, A., Restuccia, J. D., Burgess, J. F. Jr, Benzer, J., Glasgow, J., Hockenberry, J., Mohr, D. C. & Kaboli, P. J. (2014) Nurse practitioner and physician assistant scope of practice in 118 acute care hospitals. *Journal of Hospital Medicine*, 9 (10), 615–620.

26. Ross, N., Parle, J., Begg, P. & Kuhns, D. (2012) The case for the physician assistant. *Clinical Medicine*, 12 (3), 200–206.

27. Bos, W. J., Koevoets, H. P. J. & Oosterwaal, A. (2011) Ziekenhuislandschap 20/20: Niemandsland of Droomland? Den Haag: Raad voor de Volksgezondheid en Zorg.