Positive airway pressure telehealth models and long-term therapy termination: a healthcare database analysis

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Shareable abstract (@ERSpublications)
PAP therapy termination rates are lowest when telemonitoring-guided proactive care is combined with a patient engagement tool; this approach could ensure achievement of the long-term benefits associated with effective sleep apnoea treatment https://bit.ly/3RkxMkz

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Abstract

Background Telemonitoring-guided interventions can improve short-term positive airway pressure (PAP) therapy adherence, but long-term effects are unknown. This study investigated long-term PAP therapy termination in patients with sleep apnoea managed with standard care, telemonitoring-guided proactive care or telemonitoring-guided proactive care + patient engagement tool.

Methods German healthcare provider data were analysed retrospectively. Individuals aged 18–100 years who started PAP from 2014 to 2019 and had device type/interface data were included. Time-to-termination periods were analysed using Kaplan–Meier plots and Cox proportional hazards regression, adjusted for age, sex, insurance type, and device and mask type.

Results The per-protocol population (valid telemonitoring data) included 104 612 individuals (71% male; 95% aged >40 years). Mean follow-up was 3.3±2.0 years. The overall therapy termination rate was significantly lower in the telemonitoring-guided proactive care group *versus* standard care (20% *versus* 27%; p<0.001), and even lower in the telemonitoring-guided care + patient engagement tool group (11%; p<0.001 *versus* other treatment groups). Adjusted risk of therapy termination was lower *versus* standard care (hazard ratio 0.76, 95% confidence interval 0.74–0.78; and 0.41 (0.38–0.44) for telemonitoring-guided proactive care alone + patient engagement). Age <50 or >59 years and use of a nasal pillows or full-face mask were significant predictors of therapy termination; male sex, use of telemonitoring-guided proactive care (± patient engagement) and private insurance were significantly associated with lower therapy termination rates.

Conclusions Use of telemonitoring-guided proactive care and a patient engagement tool was associated with lower rates of PAP therapy termination.

Introduction

Continuous positive airway pressure (CPAP) is the standard therapy for obstructive sleep apnoea (OSA) [1]. Adherence to positive airway pressure (PAP) therapy is essential for its beneficial effects and for maximising the magnitude of these benefits [2–4]. However, suboptimal adherence is a challenging problem when CPAP is used in clinical practice, and limits the potential effectiveness of PAP therapy in daily patient care [5].

Telemedicine strategies represent a more recent approach to improving device usage and the management of PAP therapy in patients with sleep apnoea. Data from some prospective intervention trials have shown

improvements in device usage and therapy adherence with a variety of telemedicine strategies compared with standard care [6–9], but this was not the case in some other studies [10, 11]. Nevertheless, the currently available body of evidence from randomised, prospective, observational and retrospective analyses suggests a beneficial role for telemonitoring in improving usage of PAP therapy and decreasing healthcare professional workload (table 1) [6–16], although these data are highly heterogeneous in terms of factors such as patient population, interventions investigated and outcome parameters. When data from 33 published studies enrolling a total of 8689 participants were combined in a systematic review and meta-analysis, use of telemedicine strategies for the management of follow-up in individuals with OSA had a beneficial effect on compliance and was more cost-effective than standard care [17].

The availability of cloud-connected devices and the opportunity afforded by big data analysis provides the opportunity to evaluate the effects of different telemonitoring strategies on PAP device usage and therapy termination (as the most extreme form of nonadherence) in patients managed using current technology. In this context, we were able to demonstrate that telemonitoring-guided proactive care can reduce PAP therapy termination rates within the first year of treatment [16], and that the addition of a patient engagement tool can improve device usage in the first 180 days after PAP initiation [15]. However, there is hardly any published evidence relating to PAP therapy termination rates over the longer term in patients managed using different telehealth-based care strategies.

Therefore, this big data analysis was designed to investigate long-term rates of therapy termination in patients with sleep apnoea treated with PAP therapy and managed using standard care, telemonitoring-guided proactive care, or telemonitoring-guided proactive care plus a patient engagement tool. The aim was to determine which of these approaches was most effective for facilitating the long-term continuation of PAP therapy usage.

Methods

Study design

This retrospective non-interventional study used data from a German healthcare provider (ResMed Healthcare). Part of the registration process for AirView™ included the provision of patient consent to allow the use of their anonymised PAP data to be used for research purposes. European Union medical data protection regulation allows for the use of strictly anonymised data for scientific purposes. In this study all individual patient data analysed were anonymised to comply with these regulations, and therefore specific ethics approval was not required for this study.

Study participants

Patients aged ⩾18 years who had an indication for PAP therapy (moderate-to-severe sleep apnoea, or mild sleep apnoea with significant symptoms), started PAP therapy between 2014 and 2019, had data on the type of device and interface (mask) used, and had an observation time of >0 days (indicating start of therapy) were included (figure 1). PAP therapy for all patients was initiated in Germany, where national guidelines [18] provide detailed recommendations regarding the initiation and follow-up of therapy. This includes initiation of PAP therapy during attended polysomnography, and early outpatient follow-up visit within 6 weeks after the start of treatment and then annual follow-up. Individuals using adaptive servo-ventilation or bilevel PAP therapy were excluded.

Interventions

Three patient groups were defined based on management approaches chosen/accepted by patients during their routine clinical management: those receiving standard care; those receiving telemonitoring-guided proactive care (AirView™; ResMed); and those managed using telemonitoring-guided proactive care and a patient engagement tool (myAir™; ResMed).

Standard care

Standard care was defined as normal clinical follow-up care by the treating physician based on German guidelines [18]. These suggest that polygraphy follow-up should be performed within 6 months of therapy initiation, plus clinical visits as required; these are often annually and include download of device data.

Telemonitoring-guided proactive care

The remote telemonitoring system (AirView™) connected wirelessly with the PAP devices. AirView™ is a Health Insurance Portability and Accountability Act-compliant, password-protected cloud-based technology. PAP device data are transferred automatically to AirView™ on a daily basis to help clinicians remotely manage PAP therapy and compliance. As per homecare provider standard operating procedures, if data showed that PAP usage during the first 2 weeks of therapy was <4 $h \cdot day^{-1}$, the homecare provider

TABLE 1 Summary of data from studies investigating the effects of telemonitoring on adherence to positive airway pressure therapy

Author, year	Patients (n)	Design (duration)	Comparators	Main findings
Prospective/randomised trials				
Sparrow *et al.*, 2010 [9]	OSAS (n=250) Age 48–63 years 82% male	Randomised (12 months)	TM *versus* standard care	Median observed CPAP usage at 12 months was 2.98 h per night in the TM group *versus* 0.99 h per night in the standard care group (p=0.006); corresponding adherence rates were 44.7% and 34.5%
Fox *et al.*, 2012 [6]	Moderate-to-severe OSA (n=75) Mean age 53.5±11.2 years 80% male	Randomised (3 months)	TM *versus* standard care	Mean 3-month PAP usage was 191 min·day^{-1} in the TM group *versus* 105 min·day^{-1} in the standard care group (between-group difference 87 min·day^{-1}, 95% CI 25–148; p=0.006). On days when PAP was used, usage was 321 min in the TM group and 207 min in the standard care group (difference 113 min, 95% CI 62–164; p=0.0001). Significant independent predictors of adherence were use of TM, age and baseline ESS score
Abreu *et al.*, 2013 [10]	OSA (n=51) Mean age 54 years 82% male	Randomised (4 weeks)	TM *versus* standard clinical care or weekly phone call	Mean APAP usage in the first 4 weeks of therapy was 5.0±1.8 h per night in the TM group, 5.1±2.5 h per night in the standard care group and 3.9 ±2.6 h per night in the phone call group; corresponding residual AHI values were 5.3±3.0 events·h^{-1}, 5.0±2.5 events·h^{-1} and 5.6±3.8 events·h^{-1}
Schoch *et al.*, 2013 [8]	Newly diagnosed OSA (n=293) Age 45–64 years 74% male	Prospective (30 days)	TM *versus* standard care	Patients in the TM *versus* standard care group used PAP for longer (5.2 *versus* 4.6 min per night; p=0.05) and on more nights (28 *versus* 26; p<0.001). TM use remained associated with adherence after adjustment for age and the proportion of outpatients in each group (p=0.02)
Munafo *et al.*, 2016 [11]	Newly diagnosed OSA (n=122) Mean age 51 years 69% male	Prospective (90 days)	TM *versus* standard care	Adherence rates (83% *versus* 73%), CPAP usage (5.1±1.9 h·day^{-1} *versus* 4.7±2.1 h·day^{-1}), residual AHI (3.0±4.1 events·h^{-1} *versus* 2.8±3.8 events·h^{-1}) and change in ESS score (–5.8±5.5 *versus* –5.1±5.9) did not differ significantly between the TM and standard care groups. The number of minutes of coaching required per patient was 59% lower in the TM *versus* standard care group (23.9±26.0 *versus* 58.3±25.0; p<0.0001)
Hwang *et al.*, 2018 [7]	New PAP users (n=1455) Mean age 49.1±12.5 years 49% male	Randomised, open-label (90 days)	TM-based education (Tel-Ed) *versus* CPAP TM with automated feedback messaging (Tel-TM) *versus* both strategies (Tel-both) *versus* usual care (UC)	Mean CPAP usage at 90 days was 3.8±2.5, 4.0±2.4, 4.4±2.2 and 4.8±2.3 h·day^{-1} in the UC, Tel-Ed, Tel-TM and Tel-both groups, respectively. Usage was significantly higher in the Tel-TM and Tel-both groups *versus* usual care (both p=0.0002) but not in the Tel-Ed group (p=0.10). Medicare adherence rates were 53.5, 61.0, 65.6 and 73.2% in the UC, Tel-Ed, Tel-TM and Tel-both groups (Tel-both *versus* UC, p=0.001; Tel-TM *versus* UC, p=0.003; Tel-Ed *versus* UC, p=0.07), respectively
Observational/retrospective				
Coma-del-Corral *et al.*, 2013 [12]	Suspected OSAS (n=40) Mean age 53±10.3 years 63% male	Observational (6 months)	TM *versus* standard care	The 6-month CPAP compliance rate was 75% for patients evaluated with a teleconsultation and 85% for those evaluated in the clinic. The real cost of TM was estimated to be similar to, or lower than, that of conventional PSG.
Woehrle *et al.*, 2017 [16]	New PAP users (n=6802) Mean age 59±13 years 75% male	Observational (1 year)	TM *versus* standard care	PAP therapy termination rate was significantly lower (5.4% *versus* 11.0%; p<0.001) and time to therapy termination was significantly longer (348±58 *versus* 337±76 days; p<0.05) in the TM *versus* standard care group. Cox proportional hazard analysis showed that the risk of PAP termination was significantly reduced in the TM *versus* standard care group (HR 0.48, 95% CI 0.4–0.57); findings were consistent in patient

Continued

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TABLE 1 Continued

Author, year	Patients (n)	Design (duration)	Comparators	Main findings
				subgroups by sex, PAP device type and insurance status, and in patients aged ⩾40 years
Malhotra *et al.*, 2018 [13]	New PAP users (n=128 037) Mean age 52 years	Retrospective (90 days)	TM alone *versus* TM+patient engagement tool	The proportion of patients who achieved US Medicare adherence criteria was 87.3% in the TM+patient engagement group *versus* 70.4% in the TM group (p<0.0001). Corresponding values for mean device usage were 5.9 *versus* 4.9 h per night (p<0.0001)
Woehrle *et al.*, 2018 [15]	Indication for PAP (n=1000)	Retrospective, big data analysis (180 days)	TM alone *versus* TM+patient engagement tool	The proportion of nights with device usage ⩾4 h was 77±25% in the TM+patient engagement group *versus* 63±32% in the TM group (p<0.001). Therapy termination occurred less often in the TM+patient engagement group (p<0.001). The AHI was similar in the two groups, but leak was significantly lower in the TM+patient engagement *versus* TM group (2.7±4.0 *versus* 4.1±5.3 L·min^{-1}; p<0.001)

OSAS: obstructive sleep apnoea syndrome; TM: telemonitoring; CPAP: continuous positive airway pressure; OSA: obstructive sleep apnoea; PAP: positive airway pressure; ESS: Epworth Sleepiness Scale; APAP: automatically titrating continuous positive airway pressure; AHI: apnoea–hypopnoea index; PSG: polysomnography; HR: hazard ratio.

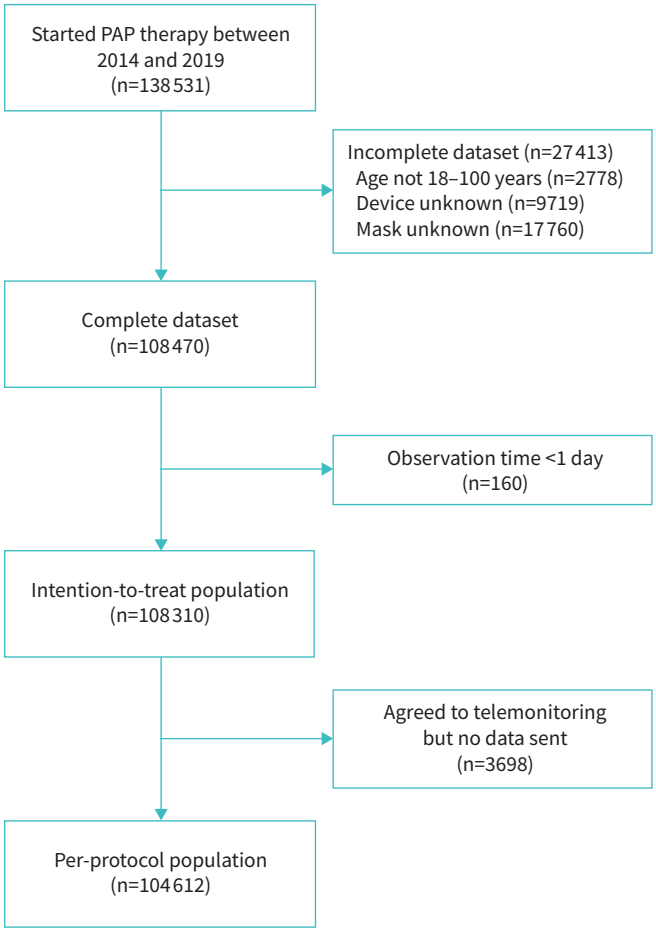

FIGURE 1 Study flow chart. PAP: positive airway pressure therapy.

contacted the patient by telephone (if authorised by the treating institution). From 2 weeks onwards, patients were notified by telephone or letter if telemonitoring data showed that PAP device usage had decreased significantly and/or fell below 4 h per night. Patients were contacted by telephone and provided with detailed information about their PAP usage and provided with strategies to overcome therapy-related issues, such as upper airway dryness, pressure and mask leak.

Patient engagement tool

The patient engagement tool provides patients with real-time feedback and coaching based on their data within AirView™. Patients sign themselves up for myAir™ and the platform is accessed *via* logging in to the myAir™ website. Interactions with the patient include: a myAir™ score, usage-based praise messages, usage-based exception messages, exception-based leak, exception-based apnoea–hypopnoea index (AHI) and "badges." The daily myAir™ score is determined based on device usage hours, mask seal (as an indicator of leak), events per hour and number of times for mask on/off. Personalised coaching/reinforcement messages are sent *via* e-mail and are designed to increase self-management skills, recognise success, and identify and resolve simple treatment issues. The messages provide general tips on how to make PAP therapy more comfortable or messages of encouragement when patients meet a certain milestone (*e.g.*, mean usage of >4 h per night).

Data extraction and definitions

A de-identified copy of all available information was provided to the physicians and statistician who performed the data analysis, similar to previous studies [14, 15]. Data extracted from the database for each patient included patient age and sex, type of PAP device (automatically titrating CPAP (APAP) or CPAP), type of insurance (public or private), and mask type (nasal, nasal pillows or full-face), therapy start date and date of therapy termination (but not device usage hours). Additional information, such as sleep apnoea

severity and comorbidities, were not available from this healthcare provider database (which contains less information than a full electronic medical record).

Outcomes

The key outcome of interest was the rate of therapy termination over at least 3 years of follow-up from initiation of PAP therapy. Therapy termination could take place at any time from the therapy start date and was defined as return of the PAP device to the healthcare provider. Reason for therapy termination had to be patient factors or physician decision; therapy termination for other reasons (*e.g.* healthcare system factors) was not evaluated. Participants were followed for at least 3 years after the initiation of PAP therapy, but therapy discontinuation could occur at any time from the time of initiation onwards.

Statistical analysis

All patients who met the inclusion criteria were included in the intention-to-treat (ITT) population. The per-protocol (PP) population included patients from the ITT population who had telemonitoring data, which would be equivalent to populations undergoing telemonitoring in clinical practice. All analyses were undertaken in both the ITT and PP populations; data from the PP population are reported because these reflect real-world clinical practice.

Numerical data are presented as mean±SD. Between-group differences were analysed using a t-test because the large sample size allows for approximation with normal distribution. Ordinal and nominal data were presented as absolute and relative frequency. Time-to-termination data were analysed using Kaplan–Meier plots and Cox proportional hazards regression, with adjustment for potential confounders (including age, sex, insurance type, device type and mask type). Statistical significance was defined as $p<0.05$ ($p<0.016$ after Bonferroni correction with three groups). All statistical analyses were performed using SPSS Version 22 and R 4.0.2.

Results

Study population

From an initial potential sample of 108 470 patients who started PAP therapy between 2014 and 2019, were aged between 18 and 100 years and had first mask and first device data available, the PP population included 104 612 patients receiving APAP or CPAP (71% male, mean age 61±13 years) (figure 1, table 2). Differences between the different patient groups were numerically small, but some did reach statistical significance (likely due to the large sample size) (table 2). The proportion of patients managed with each strategy changed over time, with increasing numbers utilising connected technologies at later dates of therapy initiation (figure 2). Mean follow-up was 3.3±2.0 years.

Therapy termination rates

The overall therapy termination rate was slightly but significantly lower in the telemonitoring-guided proactive care group compared with standard care (27% *versus* 20%; $p<0.001$) and lower again in the telemonitoring-guided proactive care + patient engagement tool group (11%; $p<0.001$ *versus* standard care and telemonitoring-based proactive care groups) (table 3). Overall, therapy termination was most likely in the first 2 years after PAP initiation (supplementary figure S1). Unadjusted Cox proportional hazard analysis showed that telemonitoring-guided proactive care reduced the risk of therapy termination

TABLE 2 Patient characteristics at baseline (per-protocol population)

	Overall	Mode of care		
		Standard care	Telemonitoring-guided proactive care	Telemonitoring-guided proactive care + patient engagement tool
Patients, n	104 612	45 927	49 360	9325
Female sex, n (%)	30 008 (29)	13 732 (30)	14 406 (29)[#]	1870 (20)[#,¶]
Age years, mean±SD	61±13	61±13	62±13[#]	57±12[#,¶]
Private health insurance, n (%)	16 516 (16)	8364 (18)	6270 (13)[#]	1882 (20)[#,¶]
Mask type, n (%)				
Nasal	52 386 (50)	21 512 (47)	26 650 (54)[#]	4224 (45)[#,¶]
Nasal pillows	15 135 (14)	6981 (15)	6560 (13)[#]	1594 (17)[#,¶]
Full-face	37 091 (35)	17 434 (38)	16 150 (33)[#]	3507 (38)[#,¶]

[#]: $p<0.016$ *versus* standard care; [¶]: $p<0.016$ *versus* telemonitoring.

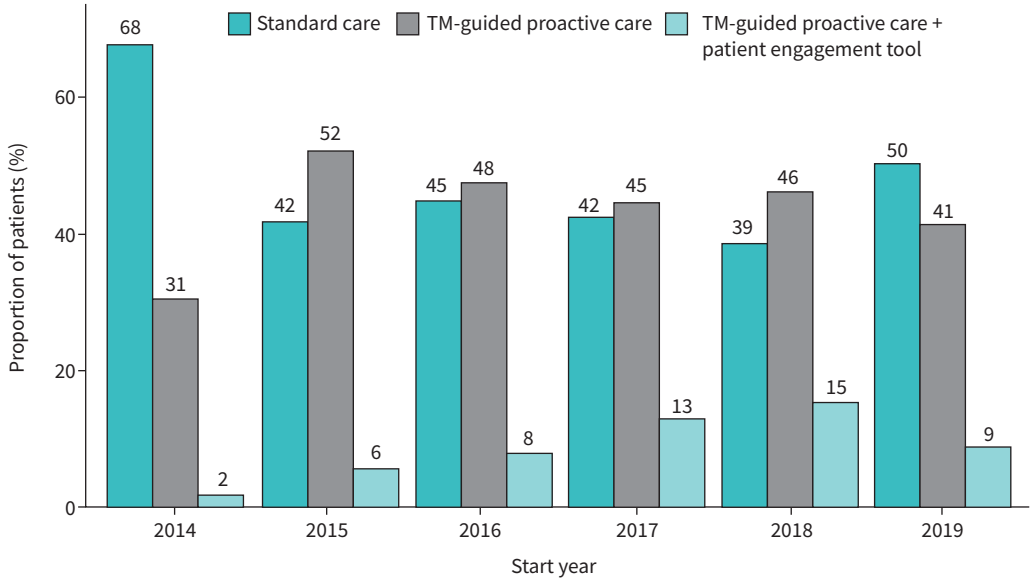

FIGURE 2 Proportion of patients managed using different strategies over time. TM: telemonitoring-guided proactive care.

compared with standard care (hazard ratio 0.79, 95% confidence interval (CI) 0.77–0.82 for telemonitoring-guided proactive care; and 0.39 (0.37–0.42) for telemonitoring-guided proactive care + patient engagement tool) (figure 3). In a Cox proportional hazard analysis adjusted for age, sex, insurance type, device type and mask type, hazard ratio (95% CI) values for therapy termination *versus* standard care were 0.76 (0.74–0.78) for telemonitoring-guided proactive care and 0.41 (0.38–0.44) for telemonitoring-guided proactive care + patient engagement tool (figure 3).

Predictors of therapy termination

Significant predictors of therapy termination were age <50 years and age >60 years (reference: age 50–60 years), and use of a nasal pillows or full-face mask (reference: nasal mask). In contrast, male *versus* female sex and having private *versus* public insurance were significantly associated with lower rates of therapy termination (figure 4). Similar patterns were seen in the standard care (supplementary figure S2A) and telemonitoring-guided proactive care (supplementary figure S2B) groups, but findings in the telemonitoring-guided proactive care + patient engagement tool group were more variable (supplementary figure S2C), probably due to the smaller number of patients in this group.

Discussion

The results of this analysis show that a telemonitoring-guided proactive care strategy, alone or in combination with a patient engagement tool, was associated with a sustained reduction in rates of PAP therapy termination over time, and that this reduction was greatest in patients managed using both telemonitoring-guided proactive care and a patient engagement tool. Results were consistent in the ITT and

TABLE 3 Termination of positive airway pressure therapy (per-protocol population)

	Overall	Mode of care		
		Standard care	Telemonitoring-guided proactive care	Telemonitoring-guided proactive care + patient engagement tool
Patients, n	104 612	45 927	49 360	9325
Observation period years, mean±SD	3.3±2.0	3.3±2.1	3.4±1.9[#]	3.2±1.4[#,¶]
Therapy termination, n (%)	23 255 (22)	12 592 (27)	9676 (20)[#]	987 (11)[#,¶]
Therapy termination in the first year, n (%)	11 071 (11)	6328 (14)	4339 (9)[#]	404 (4)[#,¶]
Therapy termination rate per 100 patient-years	6.6	7.6	6.2	3.3

[#]: p<0.016 *versus* standard care; [¶]: p<0.016 *versus* telemonitoring.

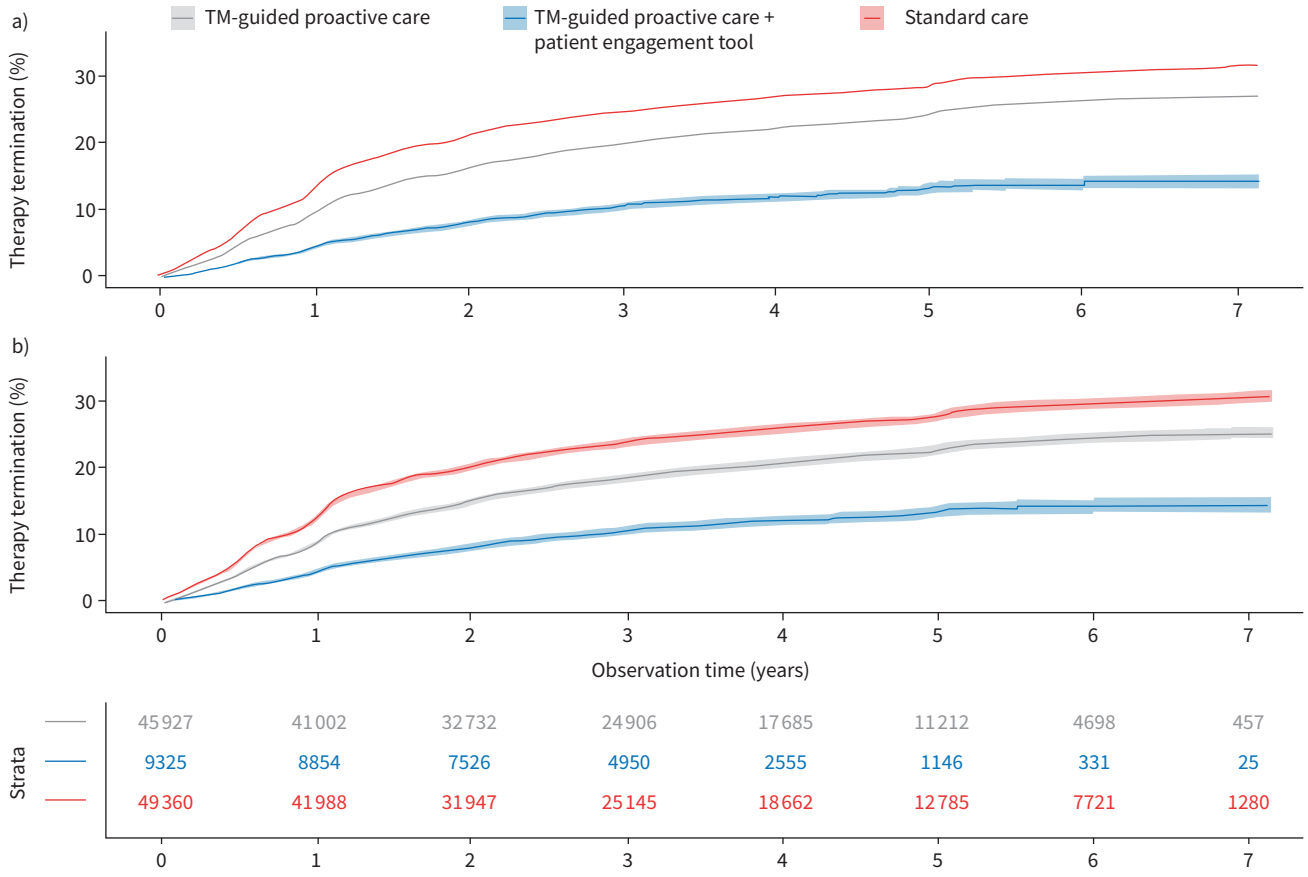

FIGURE 3 Cumulative positive airway pressure therapy terminations over time (per-protocol population) based on Kaplan–Meier analysis are shown as a) unadjusted Cox regression plots and b) Cox regression plots adjusted for age, sex, insurance type, device type and mask type. Shading either side of each line show the 95% confidence intervals. TM: telemonitoring.

PP analyses, but the magnitude of effect was greater in the PP population, which is more representative of patients managed with telemonitoring-guided proactive care in clinical practice. This is the first time that three different approaches to PAP therapy management have been compared, and our study is one of the very few currently published studies to investigate longer-term usage of PAP therapy using modern healthcare delivery models.

Lack of adherence is not directly comparable with therapy termination because some non-adherent patients may still have their devices (and therefore have the potential to use them), whereas those who terminated their therapy have returned their PAP devices. Therapy termination is thus the most extreme form of nonadherence. Despite this, our data showed that there is the potential to prevent therapy termination in the majority of patients with the use of telemonitoring-guided proactive care, and especially telemonitoring-guided proactive care plus a patient engagement tool.

In a previous long-term study of data from the Scottish National Sleep Centre, the proportion of patients who had stopped PAP therapy after 5 years was 32% [19]. In the current study, overall therapy termination rates in the intervention groups were much lower than this (21% for telemonitoring-guided proactive care and 11% for telemonitoring-guided proactive care + patient engagement tool), and the standard care group had a similar therapy termination rate (26%). A Swiss cohort study showed a gradual decline in adherence over time, which is consistent with the trajectories of the therapy termination curves in our study. The fact that the Scottish and Swiss studies [8, 19] were conducted over earlier time periods is one potential explanation for the lower rates of long-term device usage compared with our analysis. It is possible that established therapeutic advances, different patient populations and differences in standard care between countries have contributed to the lower rates of therapy discontinuation in our study compared with earlier data. Certainly, the use of newer technologies such as telemonitoring-guided proactive care and a patient engagement tool appeared to improve PAP device usage even over longer-term follow-up in our study.

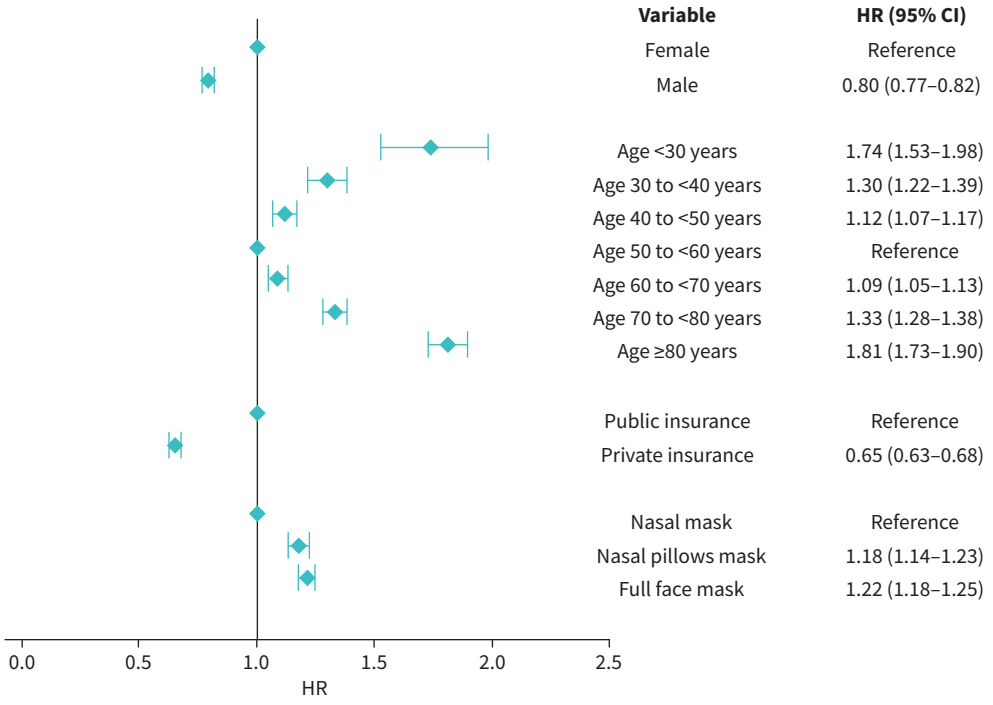

FIGURE 4 Forest plots of Cox regression analyses of potential predictors of positive airway pressure therapy termination in the per-protocol population over the full follow-up period (showing adjusted hazard ratio (HR) and 95% confidence interval (CI) values).

The Kaplan–Meier and Cox proportional hazards curves in the current study showed a gradual decline in PAP usage over time and further separation between the curves for the three different groups as follow-up time increased. This could indicate a continuing influence of the telemonitoring and telemonitoring + proactive care management strategies on treatment termination rates. We also suggest that the nature of the curves over time indicates that baseline differences between the three study groups or selection bias may not have had a marked influence on the findings because if these factors were the most important factors determining therapy termination, the curves would diverge early and run parallel during the remaining follow-up period.

In line with a previous study by our group [14], we found a U-shaped relationship between age and treatment discontinuation, with significantly higher rates of therapy termination in younger and older age groups compared to those aged 50–60 years. It is possible that the reasons underlying therapy termination could differ between age groups, but this information was not captured in the current analysis. However, older age may be associated with less adoption of the digital technologies that support adherence to PAP therapy, increasing the likelihood of therapy termination in older age groups. Also similar to the previous publication, we found higher therapy termination rates in publicly insured patients *versus* privately insured patients. This may be due to better support for privately insured individuals, for whom the number of support visits is not capped, or may reflect different socioeconomic status or proactive health behaviours of privately *versus* publicly insured individuals. However, these suggestions are speculation only. Nevertheless, our results confirm the relevance of age and type of insurance as predictors of both short- and medium- to long-term dropout rates after PAP prescription. Our data showing higher rates of therapy termination in females in this German analysis are consistent with an analysis of a large French dataset [20]. The finding that use of a nasal pillows or full-face mask was associated with a higher rate of therapy termination could be because these types of interface may be more likely to be used in individuals who are considered to be at greater risk of having interface issues during PAP therapy, but this is an area for future investigation.

Overall adherence to CPAP in randomised clinical trials has barely improved over the period 1994 to 2015 [21]. However, our results suggest that newer telemedicine strategies with proactive patient care have the potential to markedly increase the proportion of patients who remain on PAP therapy over the medium term.

A recent meta-analysis also confirmed that telemedicine strategies are in general associated with improved short-term adherence to PAP therapy in OSA patients, showing a clinically relevant increase in device use of >0.5 h per night [22]. The authors did note that it is still unclear which specific telemedicine intervention can be most effectively implemented in clinical practice [22]. The big data analysis presented herewith uses data from routine clinical practice and showed that two specific telemedicine strategies were associated with a reduction in long-term treatment termination rate in patients receiving PAP therapy.

The main strengths of this study are the large dataset collected during routine clinical practice and the analysis of PAP therapy termination over a 6-year period. However, there are also some limitations that need to be considered when interpreting our results. This is a retrospective analysis using a database created for administrative rather than scientific purposes. This means that data on potentially important variables such as the method used to diagnose sleep apnoea, the severity of sleep apnoea, the presence of daytime sleepiness and comorbidities, and therapy parameters such as pressures or use of heated humidification are missing. ResMed Healthcare is one of the largest healthcare providers of PAP devices in Germany, and choice of healthcare provider is made by patients and physicians. Given the size of the sample, this should be representative of the wider German population of PAP users. However, generalisability of the findings to other populations in Germany and those from other regions should be done with caution. The three groups examined in our study were formed by individual decisions of each patient and their physician (*i.e.* self-selected) rather than in a prospective randomised manner. This selection bias means that our results could have been influenced by a variety of confounding variables. However, the persistent way in which the treatment termination curves diverge over time is an indicator of a probable real effect of the different management strategies studied. During the recruitment phase, the number of patients who opted for the telemonitoring-guided proactive care and patient engagement options increased steadily. This most likely reflects increases in the availability of these tools and awareness of their potential benefits over time. However, this also means that the proportion of patients managed using the combination strategy (*i.e.* telemonitoring-guided proactive care with the patient engagement tool) was comparatively low in the overall study population (~9%). Accordingly, larger, preferably randomised, studies are needed to confirm our results. Based on the trends described above, it should be easier to include a higher proportion of patients with the patient engagement tool in such a new study. Finally, this study focused only on two distinct groups – those who terminated therapy and returned their device and those who continued using PAP therapy. There are no data on patients who did not terminate therapy but had low device usage, because PAP device usage hours were not available for the standard care group and were not accessible for the other groups due to data protection requirements. This would be an interesting area of research for future studies. Nevertheless, therapy termination is an objective and clinically relevant end-point that is increasingly being investigated with respect to PAP therapy [20].

In conclusion, use of telemonitoring-guided proactive care was associated with lower PAP therapy termination rates compared with standard care. The addition of a patient engagement tool was associated with even lower therapy termination rates, and may therefore contribute to prevention of long-term therapy termination. Based on these associations, it is possible that PAP-treated patients who are managed using telemonitoring-guided proactive care and a patient engagement tool could be more likely to experience the long-term benefits associated with effective sleep apnoea treatment. These data highlight the value of personalised healthcare that provides feedback and interventions tailored to the needs of the individual patient to maintain long-term device usage in patients with PAP therapy.

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