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SCIENTIFIC INVESTIGATIONS

Asset life span in a government funded CPAP device program

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Study Objectives: To determine the life span of devices in a government long-term continuous positive airway pressure (CPAP) device loan program.
Methods: Retrospective review of CPAP devices provided under the Queensland Health Sleep Disorders program in Queensland, Australia, from data recorded in an in-house database that has collected data since 1995. Primary outcomes were hours of use and age of device at end-of-life. Device survival analysis was performed collectively for all devices and for different models. Reasons for device end-of-life were compared between models.
Results: There were 9,222 CPAP devices provided on long-term loan over this period, with asset end-of-life date available in 90%. Median life span was 15,178 hours (interquartile range 8,167–20,296 hours) and 12.4 (interquartile range 7.6–18.8) years. Five percent of devices were condemned in the first 3 years, and 13% of devices were condemned in the first 5 years. There were significant differences in survival patterns between different models, but after correction for run hours, only one model differed (related to manufacturer policy to replace not repair equipment). Reasons for end-of-life differed between models ($P < .001$) with manufacturer recall, excessive noise and faulty buttons the most common reasons.
Conclusions: Government CPAP loan programs can develop asset management plans with an anticipated average asset life span of 15,178 hours or 12.4 years; however, they should also plan for the need to replace equipment where earlier failure occurs. Early equipment failures are seen with variability between models, and appropriate warranty periods to cover these early failures should be negotiated with manufacturers.
Keywords: CPAP device, life span, durability, government equipment loan programs
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BRIEF SUMMARY
Current Knowledge/Study Rationale: To date there are no validated data on the life span (durability) of continuous positive airway pressure devices used on government long-term loan programs. Anticipated life span is an essential component of asset management and planning for equipment replacement.
Study Impact: We report a median continuous positive airway pressure device life span of 15,178 hours of use and 12.4 years of age. However, there are significant differences in performance between different models.

INTRODUCTION

There are numerous publicly funded programs worldwide for the provision of continuous positive airway pressure (CPAP) equipment to patients with sleep-disordered breathing. Even within Australia, there are multiple independent state-based programs. The oldest of these is the Queensland Health Sleep Disorders Program. This program was established in 1994 for the long-term loan of CPAP devices (and later bilevel devices) to disadvantaged patients. The Princess Alexandra Hospital is one of 10 prescriber units in Queensland. CPAP devices are provided on long-term loan to eligible patients who have completed a 2-month self-funded trial of treatment with adequate usage and clinical benefit. Patients must fund their own mask and other accessories, including heated humidification. Devices undergo electrical safety checks before issue and every 5 years under state legislative requirements. Devices are also visually inspected at each clinic visit. Nine hundred fifty-three CPAP devices were provided to patients for long-term loan in 2019. Of these, 633 (66%) were new devices and the rest were reissued equipment previously used by other patients. As in most areas of health care, there are significant budgetary pressures on this program to meet demand, including not just the costs of devices for new patients to the program but also funding replacement devices for existing patients where previous equipment is at end-of-life. An important component of any asset management is the strategic planning to replace devices at the end of their life span. The international standard for asset management (ISO 55000:2014) defines asset management as "the coordinated activity of an organization to realize value from assets," which depends on asset performance evaluation, including asset life (defined as the period from asset creation to asset end-of-life).[1] Unfortunately, to our knowledge, there are no data on the projected life span of CPAP devices for the development of asset management plans and specifically to strategically plan for replacement of devices at end-of-life.

The aim of this study was to retrospectively review the life span of devices provided by our institution, a tertiary hospital sleep service, through the government-funded Queensland Health Sleep Disorders Program, and to describe the pattern of equipment failure over time and between different devices utilizing an in-house database that was first developed shortly after the government program was introduced in 1994.

Table 1—Device details by model.

Device	Years Supplied	Number Supplied	Unknown Status		Confirmed Condemned	
			Number	Proportion	Number	Proportion
A	1994–1996	187	42	22%	145	76%
B	1996–1999	618	243	39%	365	60%
C	1999–2002	553	242	44%	275	50%
D	2002–2005	978	403	41%	518	53%
E	2005	46	12	26%	29	63%
F	2005–2008	1,592	0	0%	802	50%
G	2008–2012	1,651	0	0%	495	30%
H	2012–2016	2,569	0	0%	164	6%
I	2016–	1,028	0	0%	0	0%
		9,222	942	10%	2,793	30%

Models of continuous positive airway pressure devices included in the study with years available and number of devices supplied to patients of the Queensland Health Sleep Disorders program. Unknown Status refers to devices where the outcome was not recorded (overall 10% of devices). Confirmed Condemned refers to devices with a recorded end-of-life date.

METHODS

The study was a retrospective review of CPAP devices provided on long-term loan to patients of a single tertiary institution in Brisbane, Queensland, under the state-wide government-funded Queensland Health Sleep Disorders Program. Data were retrieved from a Filemaker Pro database (Claris International, Santa Clara, CA) that has been used prospectively since 1995 for recording of operational and clinical data, including equipment inventory and management. CPAP device parameters included manufacturer and model, date of acquisition, device functional status, peak run hours recorded by the device hour meter (where available), date of condemnation, and reason for condemnation (where applicable). Characteristics of the patients using the government CPAP devices, including sex, age, highest educational status, smoking status, and socioeconomic status, were assessed. Socioeconomic status was assessed with the Socio-Economic Indexes for Areas (SEIFA) 2011 developed by the Australian Bureau of Statistics,[2] which ranks areas in Australia in deciles (1 representing greatest disadvantage and 10 representing least disadvantage). Three indices were used: Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), the Index of Education and Occupation (IEO), and the index of Economic Resources (IER) calculated form the patient's residential postcode.

The primary outcome measure was device life span (both in terms of age of the device and cumulative hours of usage) at asset end-of-life. Secondary outcome measures were equipment survival patterns (collectively for all devices and between models) and reason for condemnation.

Statistical analysis

The study was approved by the Human Ethics Research Committee of Metro South Health, Queensland. The life span of devices was assessed by survival analysis. Where the exact end-of-life date was unknown, devices were censored at the last recorded date of functioning. The life span of all devices was assessed collectively by Kaplan-Meier Survival analysis. The life spans of different devices were compared by log-rank survival analysis and by Cox regression (stratified model) to correct for the effects of hours of use. Reasons for condemnation between different devices were compared by chi-square analysis, excluding devices intentionally damaged. Data (which were nonparametric) are presented as median [interquartile range]. $P < .05$ was considered statistically significant.

RESULTS

Devices

There were 9,222 CPAP devices acquired for long-term loan dating from 1994. There were 9 CPAP models used over this period. Device details are shown in **Table 1**. Outcome details including date of asset end-of-life were not available in 10% of devices. Incomplete outcome data were exclusively seen in devices acquired in or before 2005 (affecting up to 44% of device models from this period). Hours of use data were not available for the oldest 2 devices (models A and B). Overall, 30% of devices have been condemned over the study period.

Patient data

Characteristics of patients receiving long-term loan CPAP devices are shown in **Table 2**. Both sexes were well represented. Patients were generally middle aged, and the majority were without tertiary education. Patients were relatively socioeconomically disadvantaged, with a median Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) at the fifth decile. 4.3% required interpreters.

Device survival

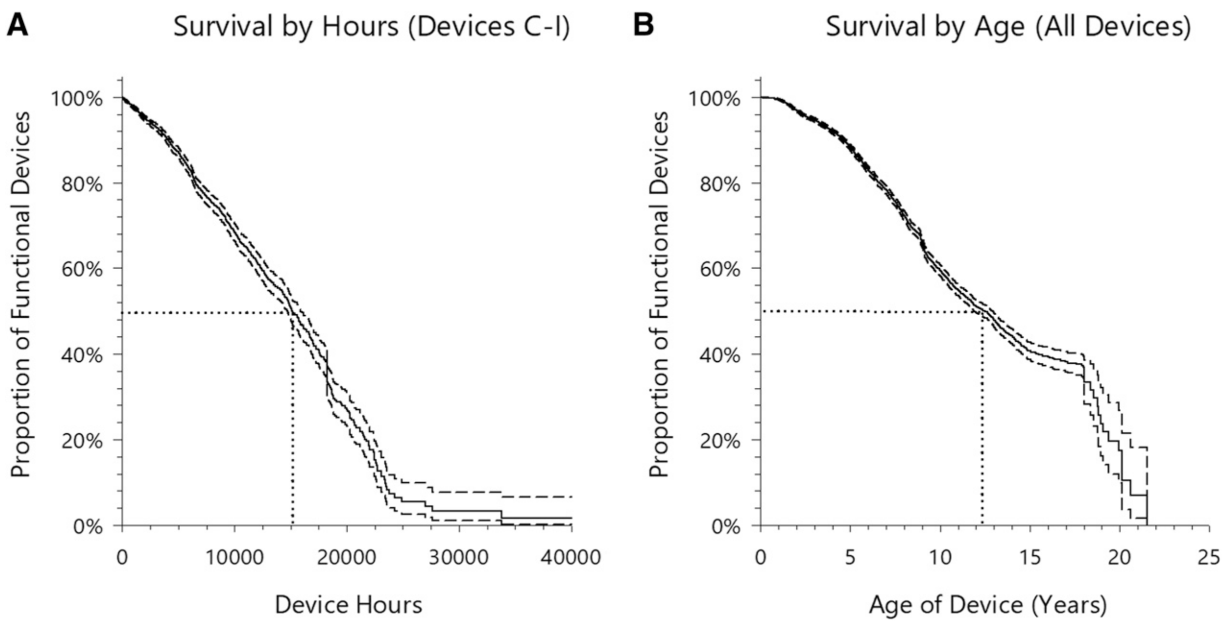
The life span (survival) of all devices is shown in **Figure 1**. Median life span by run hours was 15,178 hours [interquartile

Table 2—Patient characteristics.

	Male (n = 5,178)	Female (n = 3,507)	All (n = 8,685)
Age	64.7 [54.5–72.0]	63.8 [53.5–71.2]	64.3 [54.1–71.1]
Socioeconomic decile			
Level of disadvantage	5 [2–8]	5 [2–8]	5 [2–8]
Education	4 [2–6]	4 [2–7]	4 [2–6]
Economic	5 [3–8]	5 [3–7]	5 [3–8]
Highest education			
Still at school	<1%	<1%	<1%
Did not complete school	45%	50%	47%
Completed school	11%	13%	12%
University	8%	10%	9%
Other postschool study	35%	27%	32%
Non-English speaking	3.8%	5.2%	4.3%
Smoking status			
Never smoker	80.4%	82.4%	81.3%
Former smoker	8.1%	6.8%	7.5%
Current smoker	11.5%	10.8%	11.2%

Characteristics of patients receiving continuous positive airway pressure devices on long-term loan from the Queensland Health Sleep Disorders Program. Data are shown as median [interquartile range]. Socioeconomic Deciles were derived from the Australian Bureau of Statistics Socio-Economic Indexes for Areas estimated from residential postcode; Level of Disadvantage from the Index of Relative Socio-Economic Advantage and Disadvantage; Education from the Index of Education and Occupation and Economic from the Index of Economic Resources. See Reference 2 for details of these measures.

Figure 1—CPAP device survival.

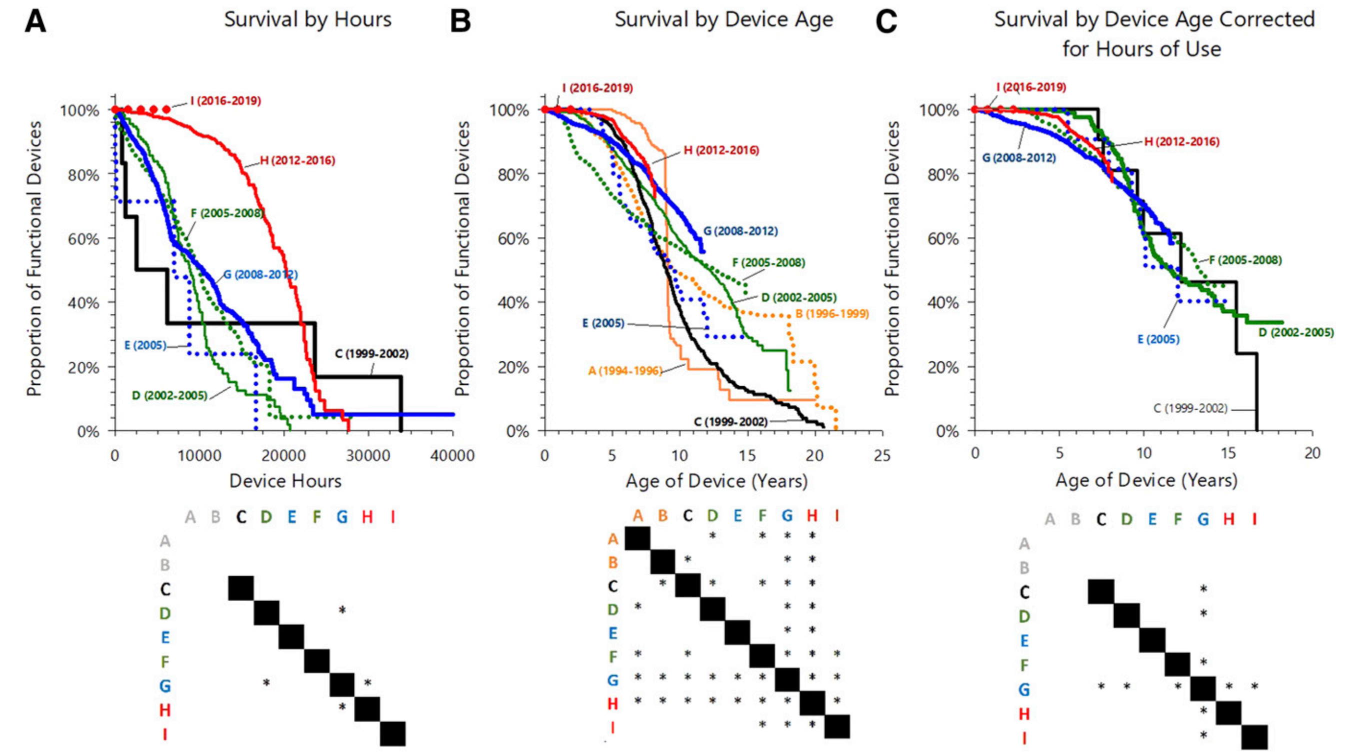


Kaplan-Meier survival curve representing the proportion of functional CPAP devices relative to the run hours of the device **(A)** or to the age of the device **(B)**. Dashed lines indicate the 95% confidence interval. Reference lines indicate the median values. Device hours data were not available for models A and B. CPAP = continuous positive airway pressure.

range 8,167–20,296 hours] (**Figure 1A**). Median life span by age of device was 12.4 years [interquartile range 7.6–18.8 years] (**Figure 1B**). Five percent of devices were condemned in the first 3 years, and 13% of devices were condemned in the first 5 years. The oldest device at time of condemnation was 21.6 years.

The life span of the different models is shown in **Figure 2**. There were significant differences in life span by run hours

Figure 2—Device survival by model.



Log-rank survival curves representing proportion of functional devices relative to device run hours **(A)** and device age **(B)** for each device model. Survival curve by age of device adjusted for device hours (Cox stratified model) **(C)**. Statistical differences are shown in the grid below each curve. *P < .05. Device hours data were not available for models A and B.

between device G and both devices D and H (**Figure 2A**). There were significant differences between models (P < .001 overall) when compared by device age (**Figure 2B**). The survival by age of models G and H differed from all other devices. Other significant differences are shown in **Figure 2B** (lower panel). Two models were subject to manufacturer recall (model A approximately 9–10 years after acquisition and model F in the first 2 years of acquisition). The proportion of functional devices at an age of 5 years varied from 71% to 100% and at 10 years between 21% (model A, which had been subject to a manufacturer's recall) to 68%. Model B demonstrated a more rapid failure rate after a threshold of 18.4 years, but the rate of asset end-of-life was more consistent with most devices. However, when corrected for run hours, only model G demonstrated significant differences from other models (**Figure 2C**). There was an earlier condemnation rate of this model, with approximately 6% of devices condemned in the first 2 years of operation. The suppliers of model G did not have local facilities for repair of equipment and therefore condemned devices for faults that were potentially repairable.

Reasons for asset end-of-life

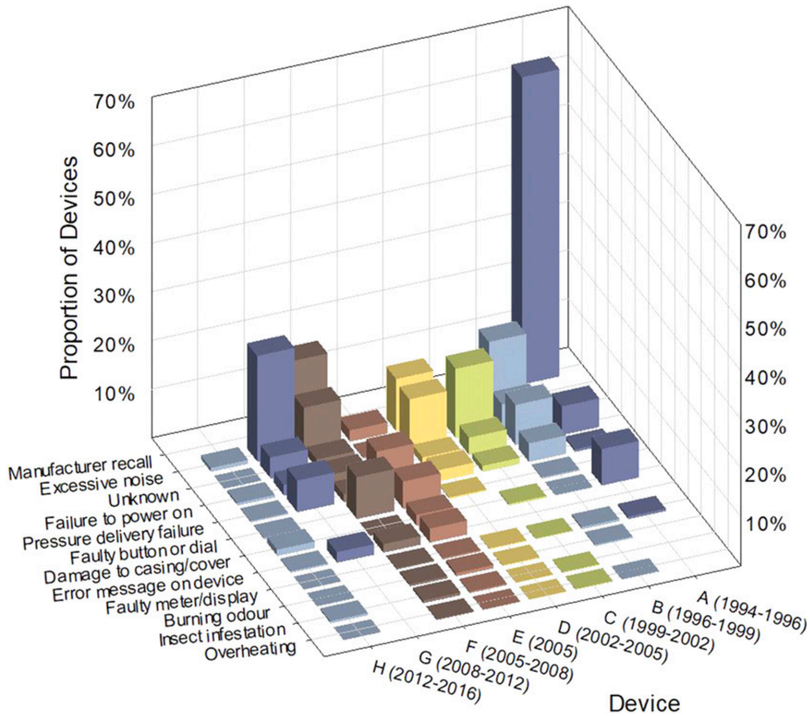
Some 2,797 devices have been condemned (30.3% of all devices). Of these, 92 devices (1% of all devices) were condemned due to patient neglect or intentional damage. A further 600 devices (6.5%) were replaced due to age alone (9.4 [8.2–11.0] years). The reasons for condemning other devices are shown in **Figure 3**. Reasons were significantly different between devices (P < .001). Two devices (devices A and F) were subject to a manufacturer recall. Excessive noise was most problematic with devices B, D, F, and G. Devices E and F were vulnerable to a faulty button or dial. Device A was most likely to be condemned due to damage in the casing.

DISCUSSION

There are numerous government-funded CPAP programs across the world, including Australia, Canada, and the United Kingdom. An essential aspect of asset management and planning for replacement of equipment at asset end-of-life is an estimation of equipment life span. We are not aware of any other published data on the life span of CPAP devices and no specific data on life span of devices provided on long-term loan. Our data have demonstrated a median asset life span of 12.4 years (15,178 hours of operation). Life span by age of device is dependent both on the intrinsic durability of the device itself as well as the hours of use. Arguably, the age of the device is a more useful measure of life span. The device warranty is defined by device age. In addition, asset management planning by time is simpler than planning by usage of device.

There is limited information provided by manufacturers on equipment life span but, where available, it suggests a life span of only 3–5 years.[3] Patient support forums discuss replacing

Figure 3—Reasons for device end-of-life.



Major reasons for end-of-life and proportions of each model affected. Device I (from 2016) is not included as none have reached end-of-life. There were significant differences in end-of-life reasons between models ($P < .001$).

CPAP devices across a wide age range of every 2–7 years,[4–6] although this is usually based more on insurance eligibility than device durability. We have demonstrated that the actual life span of CPAP devices is greater than the speculated life span by device manufacturers or CPAP users themselves. Approximately 15% of devices last over 20 years. However, a similar proportion of devices have early failure (13% in the first 5 years and 5% in the first 3 years). In fact, 27% of 1 device (device F 2005-2008) were condemned within the first 5 years (in this case related to a manufacturer recall).

Our study has also demonstrated variability between devices in terms of life span and failure pattern. Most devices show a progressive failure rate (rates differing between devices) but at least one showed a threshold after which there was a rapid increase in the rate of device end-of-life rates. Another obvious impact on device life span is the effect of manufacturer recalls. Two devices were subject to manufacturer recall, one occurring about 8–10 years after acquisition and well beyond the manufacturer warranty expiry. In addition, manufacturer policy and resources affect device life span. Life span in years corrected for hours of usage was different in only the one device where there were no local maintenance or repair facilities, which resulted in condemnation of devices that otherwise could be been repaired if such facilities were available.

The mechanism of device failure is also variable between devices. Other than manufacturer recall, the most common patterns of device failure are excessive noise, failure to power on, pressure delivery failure, and faulty buttons or dials. Some patterns of device failure are specific to more modern devices (notably error messages on the device). Interestingly, insect infestation (seen only in less than 1% of devices) occurs in some but not all devices, suggesting vulnerability of some designs. Brisbane has a subtropical climate that may influence the risk of insect infestation.

The patient profile is likely to be representative of other publicly funded government equipment programs. Patients were middle-aged and moderately disadvantaged. Approximately 60% of patients have no tertiary education. We believe that this cohort provides external validity to extrapolate the results to other programs. There was only a small proportion of devices condemned due to neglect or intentional damage (< 1%).

The results of this study have significance for planning of government programs for long-term loan of CPAP devices. The reported median life span of 12.4 years can be used in the planning and resource allocation for replacement of devices as they come to end-of-life. The study has also provided insight into the importance of an appropriate manufacturer warranty period. There is a not insignificant early failure rate of devices (in the first 3–5 years). The procurement processes for publicly funded CPAP equipment should seek a warranty period of at least 3 years, although 5 years would be preferable. Finally, the study has shown difference in failure rates and patterns between specific devices. Therefore, government programs need an effective quality program to monitor equipment performance and rapidly identify devices with suboptimal performance.

Our study has a number of strengths. Over 9,000 devices were included in the dataset including equipment dating from 1995. Incomplete outcome data overall was only 10% but is complete since 2005. However, there were incomplete data on devices acquired before 2005 (up to 44%), which is a potential weakness of that dataset. The other weakness of the study is the lack of run hours data in 2 of the oldest devices (models A and B).

In summary, this study has demonstrated a median asset life span of 12.4 years for CPAP devices on long-term loan in a publicly funded program for disadvantaged patients. There is variability between different devices. As such, these types of programs can develop asset management plans with an anticipated average asset life span of 12.4 years but must also plan for earlier replacement in view of the not insignificant equipment failure rates seen well below this age. Government procurement processes should aim to negotiate manufacturer warranty periods to cover potential early failure (we suggest a minimum of 3 years but preferably 5 years).

ABBREVIATION

CPAP, continuous positive airway pressure

REFERENCES

1. International_Organization_for_Standardization (2014). Asset management—Overview, principles and terminology (ISO15000). https://www.iso.org/standard/55088.html. Accessed April 30, 2020.
2. Australian Bureau of Statistics (2018). SEIFA 2011. https://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa2011. Accessed May 5, 2020.
3. ResMed. CPAP life expectancy: How long do CPAP machines last? https://www.resmed.com/en-us/sleep-apnea/sleep-blog/cpap-life-expectancy-how-long-do-cpap-machines-last/. Accessed April 30, 2020.
4. Sleep Apnea Guide. How often to replace the CPAP machine? https://www.sleep-apnea-guide.com/how-often-to-replace-the-cpap-machine.html. Accessed 30 April, 2020.
5. Reddit. How long do CPAP machines usually last? https://www.reddit.com/r/CPAP/comments/bb6r5c/how_long_do_cpap_machines_usually_last/. Accessed April 30, 2020.
6. Answers. How long does a CPAP last? https://www.answers.com/Q/How_long_does_a_cpap_last Accessed April 30, 2020.

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DISCLOSURE STATEMENT

All authors have seen and approved this manuscript. The authors report no conflicts of interest.