Delivery of oxygen by standard oxygen flowmeters

The last year has seen hospitals worldwide face multiple challenges in the face of the COVID-19 pandemic. This has included oxygen shortages, both locally [1] and nationally [2]. Guidance was offered by the Medicines and Healthcare products Regulatory Agency to manage this high oxygen demand [3]. We tested several standard oxygen flowmeters connected to our hospital's 400 kPa pipeline oxygen supply at 5, 10 and 15 $l.min^{-1}$ and maximum flow rate using an electronic flowmeter (Certifier FA Plus 4080, TSI Incorporated, MN, USA) using a 1 m length of standard green bubble oxygen tubing. We found that the tested flow was within 5% of the indicated value, which is within reasonable limits given the difficulty in perfectly aligning the float. When the flowmeters were fully opened, however, and the float moved beyond the calibrated markers, the maximum flow rates measured were between 65 and 75 $l.min^{-1}$ (Table 1). It has been previously reported that standard oxygen flowmeters can deliver up to 40 $l.min^{-1}$ [4], but our measurements suggest this could be a large underestimate.

A point prevalence survey of our emergency department resuscitation room and operating theatres' recovery areas demonstrated that, during one day, 17 out of 21 patients who were wearing an oxygen mask with a reservoir bag or a Mapleson C circuit were receiving oxygen at a flow in excess of 15 $l.min^{-1}$. This could potentially represent a 400% excess use of oxygen in patients who are prescribed 15 $l.min^{-1}$.

Assuming only two patients in a hospital are receiving this excess flow of oxygen at a given time, this could waste up to 7200 $l.h^{-1}$ or 172,800 $l.day^{-1}$ (representing approximately 10% of our total oxygen use). Extrapolated across a year, this would represent 63 million litres in one hospital, or 12.6 billion litres across the 200 acute hospitals in the UK National Health Service (NHS). This carries significant environmental and financial impact [5]. Furthermore, there may also be direct implications for patient safety. Unknowingly administering oxygen well in excess of 15 $l.min^{-1}$, especially with a semi-closed breathing system, may mask the true severity of a patient's condition and delay their progression to a more appropriate mode of respiratory support.

There needs to be awareness among healthcare workers that it is important to administer oxygen as prescribed, and that if higher flows of oxygen are used intentionally, a high-flow rotameter should be used in order that oxygen use can be measured accurately, rather than simply turning a standard flowmeter up beyond the calibrated graduations.

Figure 1 An example of the measured flow rate when a flowmeter is fully opened.

Table 1 Indicated and measured flow rates with oxygen flowmeters.

	Measured rate $l.min^{-1}$			
Indicated rate	**Therapy equipment Ltd 9505[a]**	**Oxylitre F1601[b]**	**Penlon O_2 Flowmeter[c]**	**Medishield O_2 Flowmeter[d]**
5 $l.min^{-1}$	5.06	5.12	5.08	5.13
10 $l.min^{-1}$	10.32	10.26	10.11	10.47
15 $l.min^{-1}$	15.69	15.38	15.63	15.51
Fully open	75.53	66.98	65.62	71.86

[a]Therapy Equipment Ltd, Potters Bar, UK.
[b]OxyLitre Ltd, Manchester, UK.
[c]Penlon Limited, Abingdon, UK.
[d]Medishield, Guildford, UK.

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Self-citations and the quality of anaesthesia research

In a recent editorial, Myles [1] discusses various tools (and some of their weaknesses) used for judging the quality of anaesthesia research. It goes on to describe the h-index, which is widely used and readily calculable using various platforms. An h-index of 35 means that the author has 35 publications (or more), each of which has at least 35 citations. There are two principal problems with this metric. The first is that it gives limited recognition to researchers who have produced truly ground-breaking, high-impact research but with a relatively small overall number of papers, as their h-index can never be greater than the total number of papers they have published. The second is that it is influenced by self-citations and reciprocal citations.

The k-index [2] addresses both these problems and has been demonstrated to correlate well with scientific prizes and other markers of excellence. In simple terms, a k-index of 35 means that an author has 35 citations from papers that have each been cited at least 35 times themselves. In an extreme example, our author may only have written one paper but still achieves a k-index of 35 when the maximum possible h-index would be 1. Self-citation in general medical literature has been explored [3] and although the practice is inherently neither bad nor good [4] it does affect citation indices. When assessing the scientific excellence of a body of a researcher's work, external citations are considered most relevant for evaluative purposes [5].

The original paper describing the k-index [2] gives examples of how the h-index and k-index would assess the worth of Einstein's contribution to the world of physics, and also shows how they can uncover unusual patterns in publishing that could indicate a need for further investigation.

While the k-index is probably superior to the h-index for evaluating scientific excellence, it is unlikely we will ever find a simple single metric to answer the complex question of how important an individual's contribution to a specialty really is. To paraphrase the San Francisco Declaration on Research Assessment referenced in the Myles editorial [1], we need to read what people write, listen to them speak and then make our minds up.

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