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LABORATORY STUDY

The precautionary principle: what is the risk of reusing disposable drops in routine ophthalmology consultations and what are the costs of reducing this risk to zero?

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Abstract

Background **Instilling eye drops is a ubiquitous procedure in eye clinics. This audit aimed to assess the risk of contamination of disposable droppers and to quantify the financial and waste implications of reducing this risk to zero by using disposable droppers only once.**

Methods **A total of 100 disposable Minims were used to place one drop in each eye of 70 patients. The dropper tip was then cultured for aerobic and anaerobic microbes.**

Results **Coagulase-negative staphylococcus was cultured from five samples. The contamination rate per drop application was 2.5%. The risk of cross-contamination with coagulase-negative staphylococcus would be between 1:400 and 1:80 if the bottle was reused once or six times. Reducing this risk to zero costs between £2.75 and £4.6 million per annum and generates between 6.85 and 11.42 more tonnes of paper waste and between 12.69 and 21.15 more tonnes of plastic waste than a strategy that reuses the disposable dropper.**

Conclusion **Reducing the risk of dropper contamination and subsequent cross infection has financial and environmental costs. As exposure to coagulase-negative staphylococcus is not necessarily associated with infection, it would be useful to decide acceptable risk levels for a given cost to maximise both cost-effectiveness and patient safety.**

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Introduction

Instilling eye drops is a ubiquitous procedure in adult ophthalmic practice. In many institutions it is a common practice to use one bottle of drops on multiple patients with the understanding that there is a risk of these drop bottles becoming contaminated with a variety of microorganisms.[1,2] Patients are also commonly given a bottle of preservative-free drops if they are allergic to preservatives and these too have been shown to provide a medium in which microorganisms can grow.[3] The dropper tip is more often contaminated than the residual solution in the bottle and the organisms cultured tend to be the normal commensal flora of the eye.[4] These are unlikely to cause problems but there is a risk of infection.[5] These two facts have led to the development of individual containers, which can be used on one patient as a single dose, obviating the need for preservatives, and reducing to zero the risk of cross-contamination by microorganisms commonly found on the ocular surface.[6] This audit aimed to look at contamination rates of the dropper tip in order to assess the risk of exposure to contaminants in subsequent patients (or the patient himself), if the disposable dropper were reused.

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Table 1 Indicating the different costs, both environmental and financial, of the different drop use strategies

Number of uses per drop bottle	*1*	*2*	*3*	*4*	*5*	*6*
Risk of transmission	0	0.0025	0.005	0.0075	0.01	0.0125
Potential number of patients affected	0	31 730	63 459	95 189	126 918	158 648
Cost of strategy per patient (£)	0.54	0.27	0.18	0.14	0.11	0.09
Cost of strategy applied to NHS (£)	5 495 549	2 747 775	1 831 850	1 373 887	1 099 110	915 925
Saving produced by strategy to NHS (£)	—	2 747 774	3 663 699	4 121 662	4 396 439	4 579 624
Money saved per patient put at risk (£)	—	87	58	43	35	29
Paper used per patient (g)	1.35	0.68	0.45	0.34	0.27	0.23
Paper waste reduction across NHS (tonnes)	—	6.85	9.14	10.28	10.97	11.42
Paper waste reduction per patient put at risk (g)	—	216	144	108	86	72
Plastic used per patient (g)	2.50	1.25	0.83	0.63	0.50	0.42
Plastic waste reduction across NHS (tonnes)	—	12.69	16.92	19.04	20.31	21.15
Plastic waste reduction per patient put at risk (g)	—	400	267	200	160	133

Materials and methods

An audit was conducted on 100 consecutive disposable Minims bottles (Chauvin Pharmaceuticals Ltd., Bausch & Lomb), which were used to place one drop in each eye of 70 patients. The bottles consisted of 70 proxymetacaine (0.5%) and fluorescein (0.25%) (PROXFLN) bottles and 15 each of phenylephrine (10%) and tropicamide (1%). The Minims were used to instill one drop into each eye of the patient using a standard 'no touch' technique. The Minim was then recapped and sent to the microbiology laboratory, where the top was removed and the dispensing end swabbed onto the culture plates. Each Minim was swabbed onto both Columbia horse blood agar (Oxoid Ltd., Thermo Fisher Scientific, http://www.oxoid.com/UK/blue/index.asp?c=UK&lang=EN) to look for staphylococci, and chocolatised Columbia horse blood agar was prepared by heating at 60°C to look for Haemophilus and other fastidious microorganisms. The horse blood plates were cultured under aerobic conditions at 36.5°C in an incubator. The chocolatised plates were cultured in 5% CO_2 at 36.7°C. Five clinicians were assessed. The mean number of Minims contributed by each of them was 20 (range 4–50). Each Minim contains 0.5 ml, which was found to be equivalent to 12 drops per Minim, enough for six patients. Boxes of PROXFLN, tropicamide, and phenylephrine were weighed in order to calculate the weight of plastic and paper waste produced per Minim. This was found to be 0.5 g of paper per Minim of PROXFLN, tropicamide, and phenylephrine; 1.6 g of plastic per Minim of PROXFLN and 1.8 g of plastic per Minim of tropicamide or phenylephrine. Each Minim of PROXFLN costs 39.75p (p, pence) and each Minim of tropicamide or phenylephrine costs 28.75p. It was estimated that there are 2564 practicing ophthalmologists of different grades practicing in the United Kingdom (Personal Communication from Royal College of Ophthalmologists, JEAS) and that each of these sees on an average 3960 patients per annum (average 15 patients per clinic and 264 clinics per year), meaning that ~10 153 440 patients are seen in total. It was assumed that the intraocular pressure of all of these was checked and the pupils of approximately a quarter of these dilated. Ethical approval was not required for the study, as the local institutional review board agreed that this study represented an audit of current practice with involvement in the study not altering or influencing patient care and the calculations of risk being theoretical and not involving the reuse of Minims on patients.

Results

Coagulase-negative staphylococcus was cultured from five of the samples. Each Minim was used on two eyes giving a contamination rate per drop application of 2.5% or per patient of 5%. Of the five clinicians assessed, three contaminated one Minim and one of them contaminated two Minims. The risk of cross-contamination with coagulase-negative staphylococcus was calculated as follows: This study showed that the event rate for a Minim becoming contaminated following usage is 5% (Ebc). The event rate for a known contaminated Minim causing contamination to the following user was assumed to be 5% (Ecc), although this is likely an overestimation. Contamination is a binary variable, therefore in probability terms further contamination events are not relevant once the dropper is already contaminated. Therefore, contamination events may be considered to occur only at person 1 or 2 or 3 or 4 or 5 or 6 in the sequence of dropper use, and these events are mutually exclusive. For each individual, we considered the probability of receiving a contaminated dropper, P(CDr). For person 1, this is by definition

zero (P(CDr) = 0). The probability of cross-contamination, P(CC), for each individual is calculated as: P(CC) = Ecc × P(CDr) (P(CC) = 0.05 × P(CDr)). The probability of a dropper being contaminated after usage, P(CDa), for any individual is a mutually exclusive event, and therefore additive, and is calculated as follows: P(CDa) = Ebc + P(CDr). Using these calculations, the risk of cross-contamination was shown to be between 1 : 400 if the Minim was reused once and 1 : 80 if used six times. Approximately 10 million patients are seen per annum by the National Health Service (NHS) ophthalmology services. If these strategies were rolled out across the NHS, we can see that if Minims were reused once, this would lead to a cost saving of £2.75 million and a reduction in waste of 6.85 tonnes of paper waste and 12.69 tonnes of plastic waste with ~32 000 patients put at risk of cross-contamination with Staphylococcus aureus, meaning ~£87 pounds saved for each potential cross-contamination event. If each Minim is used six times, these figures are £4.6 million, 11.42 tonnes of paper waste, 21.15 tonnes of plastic waste, 159 000 possible patient contamination events, meaning £29 saved for each potential cross-contamination event (see Table 1 for results summary).

Discussion

This paper demonstrates a number of important points. First, the cost of reducing small risks to zero is large. In 2.5% of cases using a 'no touch' technique, there is in fact some touch, leading to contamination of the Minim. This means that reusing the Minim does risk consequent infection of the next patient. In this audit, we only grew normal commensals of the eye with little potential for infectivity. However, this risk justifies the non-reuse of Minims in eyes with active infections, although any chain of infection would be broken after six patients making a large-scale epidemic unlikely. By the same token, there is also an argument for reusing these Minims in eyes in which there is no evidence of active infection. The risk of contamination is small (between 1 : 400 and 1 : 80) and this assumes 100% transmission rates, which is unlikely given the nature of the organisms found in this study. Indeed, many of the microorganisms will have come from lashes and not the mucosal surface and will not necessarily lead to consequent infection of the next patient if touch occurs to lashes and not the mucosal surface. In addition, during ophthalmic examinations there are other means by which commensal microorganisms, such as those identified in this study, may be transferred between patients. For example, many ophthalmologists evert the lower lid when putting in drops with a fingertip, and patients are likely to touch the forehead band on the slit lamp. Perhaps, the small risk associated with the reuse of Minims is dwarfed by other potential transfers of commensals in the clinic environment. In short, these estimates of risk reflect a worst case scenario with the real risk likely to be much lower. In terms of cost savings, accepting a certain level of risk of contamination would result in savings between £2.75 and £4.6 million per annum to the NHS assuming the levels of clinical activity mentioned in the methods section. In addition, several tonnes of paper and plastic waste could be avoided reducing the expense of costly landfill and the environmental impact of producing and transporting the drops in the first place. If costs were immaterial, all ophthalmologists would use one Minim per patient encounter. In the NHS, resource use in one area results in less resources for use elsewhere. It is therefore a useful exercise to decide acceptable levels of risk and to consider the costs associated with reducing negligible risks to zero.

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