An Outbreak of Fusarium Keratitis Associated With Contact Lens Wear in Singapore

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Context  Fungal keratitis is a potentially blinding condition that is rarely seen with contact lens wear.

Objective  To describe a nationwide outbreak of fungal keratitis caused by Fusarium species among contact lens wearers in Singapore.

Design, Setting, and Patients  Nationwide, hospital-based case series. All cases of fungal keratitis among contact lens wearers in all ophthalmology departments in Singapore were reviewed along with the charts of all contact lens wearers with culture-proven fungal keratitis from March 2005 through May 2006. A standardized telephone interview was conducted to obtain additional clinical information.

Main Outcome Measure  Diagnosis of Fusarium keratitis associated with contact lens wear.

Results  During the study period, 66 patients (68 affected eyes) were diagnosed with Fusarium keratitis associated with contact lens wear; the estimated annual national incidence is 2.35 cases per 10,000 contact lens wearers (95% confidence interval, 0.62-7.22). Patients ranged in age from 13 to 44 years (mean [SD], 27.1 [8.4] years), of which 32 (48.5%) were men. The vast majority (65 patients; 98.5%) wore soft, disposable contact lenses; 62 patients (93.9%) reported using 1 brand of contact lens cleaning solution (ReNu, Bausch & Lomb, Rochester, NY), including 42 patients (63.6%) who recalled using ReNu with MoistureLoc. Most patients (81.8%) reported poor contact lens hygiene practices, including overnight use of daily wear contact lenses (19.7%), and use of contact lenses past the replacement date (43.9%). The final best-corrected visual acuity ranged from 20/20 to 20/80. Five patients (5 eyes; 7.4%) required emergency therapeutic or tectonic corneal transplantation.

Conclusions  A new and evolving epidemic of Fusarium keratitis associated with contact lens wear was found in Singapore. Physicians and eye care practitioners worldwide need to be aware of the likelihood of similar outbreaks emerging among contact lens wearers.

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Fusarium keratitis associated with contact lens wear in Singapore. By February 2006, 54 patients nationwide had been identified as having this rare and unusual infection over the 1-year period. Alarmed by this apparent outbreak, we alerted Singapore’s Ministry of Health, which issued an urgent health advisory. Since then, 12 additional cases have been identified between March and May 2006. Recent reports of *Fusarium* keratitis in 122 patients in the United States and in 33 patients in Hong Kong have been confirmed and suggest that this phenomenon may be part of a global problem, with serious implications for millions of contact lens wearers worldwide. This article describes an outbreak of *Fusarium* keratitis among contact lens wearers in Singapore.

**METHODS**

This study was approved by the scientific and ethics committees of the Singapore Eye Research Institute. The attendance records and microbiology results of all ophthalmology departments in Singapore’s public hospitals (Singapore National Eye Centre, Changi General Hospital, Tan Tock Seng Hospital, and National University Hospital) were searched for patients treated for infective keratitis associated with contact lens wear from March 1, 2005, to May 26, 2006. Only patients with contact lens wear and a diagnosis of fungal keratitis were included in this case series. A contact lens wearer was defined as an individual who wore contact lenses at least once per week for the correction of refractive error. This excluded individuals who wore therapeutic contact lenses (eg, bandage contact lens wear) for a previously diagnosed ocular disease.

Fungal keratitis was defined as a corneal epithelial defect with underlying stromal infiltrate, which had a fungal organism isolated from a corneal sample (eg, corneal scrape, biopsy, or corneal button). Patients with classic features of fungal keratitis but negative corneal cultures were also included in the definition if a fungal organism could be isolated from the patient’s contact lens or contact lens case. Any atypical, infiltrative lesion with ill-defined or irregular margins, satellite or branching lesions, and especially in the presence of a ring infiltrate would raise the suspicion of fungal keratitis.

Patients were included in the study after informed consent (oral or written) was obtained. The following information was then extracted from the patients’ charts: demographic profile (including ethnic group), the type of contact lenses and solutions used, contact lens care practices, and the management and subsequent progress up until the last follow-up review. Ethnic group refers to the patient’s race that was declared by the individual on his/her national identity card. The population in Singapore is classified into the following 4 ethnic categories defined by the Singapore Department of Statistics: Chinese, Malay, Indian, and others. Because risk factors for disease prevalence may differ among different subpopulations in multiethnic Singapore, ethnic grouping is normally included in demographic profiling.

Telephone interviews also were conducted by trained interviewers to obtain further detailed clinical information. To minimize the effects of recall bias, a standardized questionnaire was produced, which included a list of soft contact lenses and contact lens solutions sold in Singapore during this period. To preserve the uniformity of these interviews, only 3 of the study’s investigators (W-B.K., J.L., S-B.L.) were responsible for administering the questionnaire.

Patients with a clinical or presumed diagnosis of infective keratitis associated with contact lens wear were routinely cultured for microbial organisms in the ophthalmology departments in Singapore’s public hospitals (Singapore National Eye Centre, Changi General Hospital, Tan Tock Seng Hospital, and National University Hospital) prior to treatment. Corneal samples or corneal biopsies were sampled from the edge or base of the infiltrate under biomicroscopy and sent for Gram staining, wet mount microscopy, and for culture by blood agar, chocolate agar, Sabouraud dextrose agar, brain-heart infusion broth, and thioglycollate broth. The patient’s contact lenses, contact lens case, and current bottle of contact lens solution (when available) were also sent for microbiological testing. For cases in which the *Fusarium* species were iso-

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**Table. Characteristics of Patients With Fusarium Keratitis**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of Patients (N = 66)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>32 (48.5)</td>
</tr>
<tr>
<td>Women</td>
<td>34 (51.5)</td>
</tr>
<tr>
<td><strong>Age, y</strong></td>
<td></td>
</tr>
<tr>
<td>≤20</td>
<td>17 (25.8)</td>
</tr>
<tr>
<td>21–40</td>
<td>43 (65.2)</td>
</tr>
<tr>
<td>41–60</td>
<td>6 (9.1)</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>44 (66.7)</td>
</tr>
<tr>
<td>Malay</td>
<td>16 (24.2)</td>
</tr>
<tr>
<td>Indian</td>
<td>2 (3.0)</td>
</tr>
<tr>
<td>Others§</td>
<td>4 (6.1)</td>
</tr>
<tr>
<td><strong>Laterality</strong></td>
<td></td>
</tr>
<tr>
<td>Right eye</td>
<td>30 (45.5)</td>
</tr>
<tr>
<td>Left eye</td>
<td>34 (51.5)</td>
</tr>
<tr>
<td>Both eyes</td>
<td>2 (3.0)</td>
</tr>
<tr>
<td><strong>Contact lens type</strong></td>
<td></td>
</tr>
<tr>
<td>Soft hydrogel disposable lenses</td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>52 (78.8)</td>
</tr>
<tr>
<td>Every 14 d</td>
<td>6 (9.1)</td>
</tr>
<tr>
<td>Daily</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>Silicone hydrogel disposable lenses</td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>5 (7.6)</td>
</tr>
<tr>
<td>Every 14 d</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>Rigid gas permeable</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td><strong>Contact lens solution</strong>††</td>
<td></td>
</tr>
<tr>
<td>ReNu with MoistureLoc</td>
<td>42 (63.6)</td>
</tr>
<tr>
<td>ReNu Multiples</td>
<td>6 (9.1)</td>
</tr>
<tr>
<td>ReNu solution (unspecified)</td>
<td>14 (21.2)</td>
</tr>
<tr>
<td>Complete solution</td>
<td>3 (4.5)</td>
</tr>
<tr>
<td>Opti-Free Express solution</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>Not specified</td>
<td>3 (4.5)</td>
</tr>
<tr>
<td><strong>Suboptimal hygiene practices‡‡‡</strong></td>
<td></td>
</tr>
<tr>
<td>No manual cleaning before storage</td>
<td>35 (53.0)</td>
</tr>
<tr>
<td>Expired lenses</td>
<td>29 (43.9)</td>
</tr>
<tr>
<td>Overnight wear (daily wear lenses)</td>
<td>13 (19.7)</td>
</tr>
<tr>
<td>Swimming</td>
<td>20 (30.3)</td>
</tr>
<tr>
<td>Others§</td>
<td>13 (19.7)</td>
</tr>
<tr>
<td><strong>Best-corrected visual acuity at presentation</strong></td>
<td></td>
</tr>
<tr>
<td>20/60 or better</td>
<td>51 (75.0)</td>
</tr>
<tr>
<td>20/80 to 20/200</td>
<td>11 (16.2)</td>
</tr>
<tr>
<td>Counting fingers or worse</td>
<td>6 (8.8)</td>
</tr>
<tr>
<td><strong>Best corrected visual acuity at last follow-up visit</strong></td>
<td></td>
</tr>
<tr>
<td>20/20</td>
<td>27 (39.7)</td>
</tr>
<tr>
<td>20/25 to 20/40</td>
<td>38 (58.5)</td>
</tr>
<tr>
<td>20/60 to 20/200</td>
<td>3 (4.4)</td>
</tr>
</tbody>
</table>

*Defined by the Singapore Department of Statistics.*†
†Figures do not add up to 100% as patients may have been using multiple solutions.
‡Figures do not add up to 100% as patients may have multiple suboptimal practices.
§Including outdoor activities such as camping and water sports.
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lated and available for further testing, identification was performed using 28S rRNA gene sequencing.23

Treatment of all cases was usually by a corneal specialist and therapy was modified according to culture results and clinical progress. The number of contact lens wearers in the country was estimated based on a Singapore population survey performed in 1998 reporting that 9% of the population wore contact lenses24 and by applying population figures for Singapore as of June 2005.25 This allowed us to estimate the annual incidence of Fusarium keratitis in Singapore, which was computed as the proportion of new cases among contact lens wearers in Singapore per year. The 95% confidence intervals for the incidence rates were determined assuming a Poisson distribution,26 and were calculated using JavaStat (http://statpages.org/confint.html).

RESULTS

Sixty-six patients (representing 68 affected eyes) were identified as contact lens wearers with fungal keratitis from March 2005 through May 2006 (TABLE). All 66 patients were identified from a search of the respective departments' medical records and microbiological results. Three patients (4.5%) were interviewed in person; information from the remaining patients was obtained from medical record reviews and telephone interviews.

There was a distinct trend that peaked in February 2006 when 15 cases were identified and declined between March 2006 and May 2006 (FIGURE 1). The patients were young (mean [SD] age, 27.1 [8.4] years), predominantly Chinese (reflecting the Chinese racial predominance in Singapore), and almost equally distributed by sex.

Contact Lens Usage and Practices

The average duration of contact lens use was 7.6 years. Contact lenses were worn between 6 and 24 hours each day on most days of the week. Almost all of the patients (98.5%) wore soft disposable lenses. The contact lenses worn by patients were from 8 different contact lens manufacturers. The majority of patients (78.8%) were using monthly disposable, soft hydrogel lenses. Six patients (9.1%) reported wearing disposable silicone-hydrogel lens; and 1 patient reported wearing rigid gas permeable lenses.

Multipurpose solutions for cleaning, rinsing, and storage of contact lenses were used by the vast majority of patients, and more than half (53.0%) did not perform manual cleaning of the lenses before storage. A total of 62 patients (93.9%) reported using the same brand of multipurpose contact lens cleaning solution (ReNu, Bausch & Lomb, Rochester, NY) prior to the onset of his/her infection. Forty-two patients (63.6%) reported using ReNu with MoistureLoc, 6 (9.1%) reported using ReNu MultiPlus, and 11 (16.7%) reported using an unspecified ReNu multipurpose cleaning solution. Another 3 patients (4.5%) reported using more than 1 brand of solution in the 3 months prior to the infection, including an unspecified ReNu solution, while a fourth patient reported using the Complete brand (Advance Medical Optics, Santa Ana, Calif) of contact lens solution exclusively. The brand of contact lens solution used could not be determined for the remaining 3 patients (4.5%).

Contact lens hygiene was classified as suboptimal in 81.8% of the patients, each of whom had at least 1 risk factor believed to predispose patients toward infections. The risk factors included the continued use of contact lenses after the planned replacement date (43.9%), the overnight use of daily wear contact lenses (19.7%), and swimming with contact lenses in swimming pools (30.3%), often without the use of goggles.

Clinical Features

Of the patients with fungal keratitis, 30 had involvement of the right eye, 34 had involvement of the left eye, and 2 had bilateral eye involvement (68 infected eyes). Nine eyes (13.2%) had been treated with corticosteroid eye drops prior to the diagnosis of fungal keratitis. At presentation, the best-corrected Snellen visual acuity in the affected eye was 20/60 or better in 51 patients (75.0%), 20/80 to 20/200 in 11 patients (16.2%), and count fingers or worse in 6 patients (8.8%) (Table).

Of the 68 eyes, 11 eyes (16.2%) had infiltrates that were described as central (involving the visual axis), 42 eyes (61.8%) had paracentral infiltrates, and 15 eyes (22.1%) had peripheral infiltrates. There were 25 eyes (36.8%) with classic fungal satellite lesions, 5 eyes (7.4%) with a ring infiltrate, and 47 eyes (69.1%) with documented anterior chamber inflammation (consisting of anterior chamber cells or frank hypopyon; FIGURE 2).

Microbiological Findings

Positive culture results were available for all 68 eyes; 58 eyes (85.3%) had Fusarium species isolated from a corneal scrape or corneal specimen and 10 (14.7%) eyes had typical signs of fungal keratitis with negative corneal cultures but had Fusarium species isolated from their contact lenses (n=7) or contact lens case (n=3). Fusarium species were also cultured from 3 of the 5 corneal buttons obtained from the 5 patients who received transplants. Opened bottles of contact lens solution were provided by 10 patients; none had Fusarium species isolated on microbiological testing.

Speciation was performed on isolates after the outbreak was recognized. However, most of the isolates collected prior to this were discarded.

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Speciation of the isolates was performed using 28S rRNA gene sequencing for 15 of the patients. There was 100% match with the sequence from Fusarium solani CBS490.63 in GenBank (http://www.psc.edu/general/software/packages/genbank/genbank.html).

Management and Clinical Outcome
A total of 44 patients (66.7%) had severe, sight-threatening lesions requiring inpatient management of their infection. The average hospital stay for the first visit was 6.5 days (range, 2-21 days). Readmissions were necessary in 4 patients (5.9%) because of infection recurrence.

In Singapore, topical natamycin 5% and topical amphotericin B (1 mg/mL) are the first-line treatment for suspected fungal keratitis because Fusarium and Aspergillus species are the most commonly isolated organisms locally.12 In more severe cases with impending or presenting corneal perforation or scleral extension, systemic antifungals such as fluconazole and itraconazole are added. Second-line treatment with topical and systemic voriconazole for nonresponsive cases was also instituted because this agent had been reported to have a broad-spectrum fungal activity, greater bioavailability, and higher aqueous and vitreous levels in the eye.25-29 Topical voriconazole eye drops were produced in-house by the hospital pharmacy via dilution of the powdered intravenous form to a 1% concentration. Systemic voriconazole requires an intravenous loading dose of 400 mg given twice in 24 hours followed by an oral dose of 200 mg taken twice daily.

For 11 eyes (16.2%) treated with topical antibacterial medications (typically with fortified cefazolin [50 mg/mL] and gentamicin [14 mg/mL]), infection resolved without the need for specific antifungal therapy; all 11 eyes had Fusarium species isolated from corneal scrapings. Forty-eight eyes (70.6%) were treated with either topical natamycin (n=20), topical amphotericin B (n=1), or a combination of both (n=27). Two other eyes (2.9%) required the addition of topical voriconazole to their treatment. An additional 7 eyes (10.3%) with more severe disease required the addition of systemic antifungals; 1 patient received oral fluconazole (200 mg twice daily), 4 patients received systemic voriconazole, and 1 patient had received oral itraconazole (400 mg twice daily) before conversion to systemic voriconazole.

Three of the patients recovered fully but 4 patients’ disease continued to progress despite systemic therapy.

In all, 5 eyes (7.4%) eventually required emergency therapeutic keratoplasty (1 for acute corneal perforation and 4 for disease progression with impending corneal perforation; Figure 2). Two patients subsequently required a second corneal transplant for primary graft failure at 12 days and 4 weeks.

Of the 5 patients who underwent corneal transplantation during the acute phase of the infection, 4 were men and 1 was a woman and they were between the ages of 19 and 43 years. Only 1 patient had received corticosteroid eye drops prior to the diagnosis of fungal keratitis. One patient had been treated previously for herpetic keratitis; a second patient had been diagnosed with seronegative arthropathy but was not receiving corticosteroids or other immunosuppressant agents. The other 3 patients had no known immunocompromising medical conditions.

Final visual outcome was fair in patients who required only medical therapy to achieve resolution of their infection (Table). The final best-corrected visual acuity was 20/40 or better at the last follow-up review for 62 eyes (91.2%). Of the 5 eyes that had sur-

Figure 2. Patients With Fungal Keratitis

A, Patient 1 has classic characteristics of fungal keratitis, which include stromal infiltrate with indistinct, feathery edges, and satellite lesions. B, Patient 2 has severe fungal keratitis that eventually required an urgent therapeutic penetrating keratoplasty.
gical treatment, vision ranged from 20/25 to 20/80. The mean postgraft follow-up period was 15 weeks (range, 7 weeks to 6 months) and no recurrence of the fungal lesions has occurred to date. All grafts have remained clear and the transplants appear successful.

**COMMENT**

This article reports a new and unusual outbreak of *Fusarium* keratitis associated with contact lens wear in Singapore. Because fungal keratitis is potentially blinding and often misdiagnosed among contact lens wearers, physicians and eye care practitioners need to be aware of the likelihood of similar cases emerging.

Worldwide, the incidence of fungal keratitis is generally low and infection among contact lens wearers is much rarer when compared with bacterial and *Acanthamoeba* keratitis. In a local case series conducted from 1991 to 1995 by Wong et al at the Singapore National Eye Centre, 15 of 29 patients with fungal keratitis were due to *Fusarium* species. Only 12 cases of *Fusarium* keratitis were diagnosed at this center from 2000 to 2004 (A.-L.T., unpublished data, 2004) and 3 of which were related to contact lens wear. The Singapore National Eye Centre is the main referral center in Singapore. Prior to our current report, the 5-year case series by Wong et al was the largest on fungal keratitis in Singapore. Extrapolating from their data, we estimated the baseline incidence of *Fusarium* keratitis in Singapore to be between 3 and 5 cases per year and that the majority of cases would be due to trauma and that no more than 1 to 2 cases would be associated with contact lens wear.

However, during the past 15 months, 66 patients have been identified with *Fusarium* keratitis related to contact lens wear, 35 of whom were treated by the Singapore National Eye Centre. Based on local data, we estimate that there are 224 800 contact lens wearers in Singapore, which suggests the national incidence of *Fusarium* keratitis to be 2.35 per 10 000 contact lens wearers per year (95% confidence interval, 0.62-7.22). This is an astounding figure, especially when compared with the annualized rates of all forms of contact lens–related microbial keratitis (ie, bacterial, *Acanthamoeba*, and fungal infections) reported in Europe (2.44/10 000 contact lens wearers in Scotland and 2.67/ 10 000 contact lens wearers in Holland) and in Asia (3.39/10 000 contact lens wearers in Hong Kong).

We are confident that this estimate is close to the actual national incidence rate because all patients from the public hospitals have been included. Only 1 other case of fungal infection associated with contact lens wear has been confirmed to have been treated independently in a private hospital or clinic (this information was obtained from the Singapore Ministry of Health, which has contacted all microbiology laboratories in Singapore and requested positive ophthalmic or contact lens–related fungal cultures). Therefore, we believe that Singapore is facing a new and unprecedented outbreak of *Fusarium* keratitis and that this is the first time that such an outbreak has been reported among contact lens wearers anywhere in the world.

While reviewing known risk factors for contact lens–associated microbial keratitis (eg, overnight use of contact lenses, swimming with lenses, etc), a majority of the patients were found to have suboptimal contact lens hygiene practices. Nonetheless, this finding cannot fully account for the outbreak. In contact lens hygiene at some point in time among contact lens users are likely to be relatively common and yet the incidence of fungal keratitis remains low.

A noteworthy finding was that the majority of patients (93.9%) reported using contact lens cleaning solutions from the ReNu line of products prior to his/her infection. While we acknowledge that recall bias may be a confounding factor, this had been anticipated when we began this study and we were able to confirm that solution details obtained through the patients’ chart review correlated accurately with patient interviews. In particular, all of the patients who had been documented in their charts as using a ReNu solution confirmed this during subsequent interviews. Specific data on the market share of ReNu in Singapore could not be obtained but was reported by the local media to be between 30% to 40% prior to February 2006 based on interviews with the Singapore Contact Lens Society and local optometric chains. Similar estimates were provided by contact lens solution manufacturers and by the Singapore Ministry of Health officials who were conducting a separate inquiry.

It is too early to speculate as to the role of these products in the current outbreak. A national case-control study currently under way will shed further light on the probable risk factors for this outbreak, including the role of contact lens solutions. Even though all sales of ReNu solutions were stopped in Singapore on February 17, 2006, twelve cases of *Fusarium* keratitis associated with contact lens wear were diagnosed between March and May 2006; 11 of these patients reported that they had continued to use ReNu contact lens solution despite media advisories to discontinue use of this product.

The treatment of fungal keratitis is challenging and the relative risk of penetrating keratoplasty is estimated to be 5.86 times higher in fungal keratitis compared with bacterial keratitis. Despite intensive medical therapy, between 25% and 35% of fungal keratitis cases can still be expected to require a corneal transplant at some stage of their infection (usually after the acute infectious event) for the treatment and visual rehabilitation of a quasi-rare, noninfective corneal scar. In the outbreak of *Fusarium* keratitis in Singapore, a significant percentage of patients (7.4%) needed urgent surgical intervention to treat or prevent acute corneal perforation and it is likely that additional cases may require subsequent corneal transplantation for residual scarring.

In more than 15% of the cases, resolution occurred without specific anti-
fungal therapy. These cases were all diagnosed at an early stage, presenting with small, superficial, paracentral or peripheral lesions. In our clinical experience with *Fusarium* keratitis in the Singapore population, we have encountered spontaneous resolution in early or small lesions, presumably due to host immunoresponsiveness, or sometimes, cessation of topical steroid usage. We also could not exclude the possibility that they had received antecedent treatment with topical fluoroquinolones by the referring physician. Topical fluoroquinolones are widely prescribed by general practitioners in Singapore and have been shown to have activity against species of *Fusarium*.42

Recognizing this outbreak of *Fusarium* keratitis, we alerted the Singapore Ministry of Health in February 2006. The Ministry issued an urgent health advisory to all medical practitioners and contact lens practitioners in Singapore on February 17, 2006, with regard to a possible outbreak of fungal keratitis related to contact lenses wear and also drew attention to an apparent possible association with the ReNu line of multipurpose contact lens solutions. A news release to the general public was also issued on February 17th warning contact lens wearers about the increasing incidence of fungal keratitis.43 On that same day, Bausch & Lomb voluntarily stopped all sales of ReNu products in Singapore. As a result of actions taken by the Ministry of Health and Bausch & Lomb, the number of cases appeared to be decreasing in the subsequent months of March, April, and May 2006. Meanwhile, we have formed a team of investigators from the various ophthalmic, epidemiological, and research institutes in Singapore and in cooperation with the Ministry of Health are pursuing the risk factors and causes of this outbreak.

Since February 2005, authorities in Hong Kong have reported a similar increase in the number of fungal keratitis cases, which resulted in the suspension of sales of ReNu in Hong Kong in February 2006. Further reports from Hong Kong have identified 33 patients with fungal keratitis since May 2005, of whom 29 reported using the ReNu contact lens solution prior to their infection.21

In the United States, the Centers for Disease Control and Prevention (CDC) issued a health dispatch44 and the Food and Drug Administration issued a news release45 in April 2006 warning clinicians and the public about 109 cases of suspected *Fusarium* keratitis in patients from 17 different states. On the same day, Bausch & Lomb suspended shipments of ReNu with MoistureLoc from its production plant in Greenville, SC, and on April 13, 2006,46 asked US retailers to stop the sale of the solution altogether. As of May 12, 2006, the CDC had received reports of 122 confirmed cases of *Fusarium* keratitis, 15 possible cases and 60 cases still under investigation from 33 US states and territories.20 An earlier CDC news release47 stated that 93 of the confirmed cases wore contact lenses, of which 59 cases (63%) reported using ReNu with MoistureLoc, 19 (20%) reported using ReNu MultiPlus, and 9 (10%) reported using an unspecified ReNu solution. The remaining 7 had used products from Advanced Medical Optics or Alcon while some of the cases had reported using multiple products prior to the infection.

On May 15, 2006, Bausch & Lomb announced a permanent worldwide recall of ReNu with MoistureLoc.48 In a statement, Bausch & Lomb said that in having excluded contamination, tampering, counterfeiting, and sterility failure, the company had now concluded that “some aspect of the MoistureLoc formula may be increasing the relative risk of *Fusarium* infection in unusual circumstances.”49 In a letter to the American Academy of Ophthalmology, Bausch & Lomb specifically mentioned alexidine, which is a disinfecting agent found in the MoistureLoc solution. While the company noted that alexidine was safe and effective, it acknowledged that under certain extreme conditions (eg, when the solution is allowed to evaporate, the solution is not regularly replaced in the lens case, when the bottle is kept open in between uses, or when the case is not cleaned properly or changed regularly) “the concentration of polymers included in the formula to enhance comfort may make the solution more likely to be contaminated with *Fusarium* in the environment.”49

**CONCLUSIONS**

In summary, we report a new and unprecedented outbreak of *Fusarium* keratitis involving contact lens wearers in Singapore. Reports from Hong Kong and the United States suggest that similar outbreaks of *Fusarium* keratitis may also rapidly emerge in other populations. By highlighting this series of *Fusarium* keratitis among contact lens wearers in Singapore, we hope to alert physicians and other eye care clinicians worldwide to maintain a high index of suspicion for fungal infection when evaluating and treating patients with contact lens–associated microbial keratitis.

**Author Contributions:** Dr Khor had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

**Study concept and design:** Khor, Aung, Saw, Wong, Tambyah, D. Tan.

**Acquisition of data:** Khor, Aung, Tambyah, A.-L. Tan, L. Lim, Chan, Heng, J. Lim, Loh, Lee.

**Analysis and interpretation of data:** Khor, Aung, Saw, Wong, Tambyah, Beuerman, Chan, Lee, D. Tan.

**Drafting of the manuscript:** Khor, Aung, Saw, Wong, Tambyah, Chan, J. Lim, Loh, D. Tan.

**Critical revision of the manuscript for important intellectual content:** Khor, Aung, Saw, Wong, Tambyah, Beuerman, L. Lim, Heng, Lee, D. Tan.

**Statistical analysis:** Aung, Saw, Wong.

**Obtained funding:** D. Tan.

**Administrative, technical, or material support:** Khor, Aung, Saw, Tambyah, Beuerman, Heng, J. Lim, Loh, Lee, D. Tan.

**Study supervision:** Aung, Saw, L. Lim, Heng, D. Tan.

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