Ocular involvement in melioidosis: a 23-year retrospective review

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Abstract
Background: Ocular involvement in melioidosis is rare and has devastating outcomes. Although there have been few reports on the condition, Khon Kaen, a city in northeast Thailand, has been called the “capital of melioidosis” due to the high prevalence of the condition in the region. We retrospectively reviewed all admitted cases of melioidosis with ocular involvement from the two largest hospitals in Khon Kaen. We reviewed cases from Srinagarind Hospital (a university hospital) of patients admitted between 1993 and 2016 and from Khon Kaen Hospital (a provincial hospital) of patients who presented from 2012 to 2016.

Results: We identified 16 cases of ocular involvement. Eight of these cases were proven from positive culture, and the remaining eight were implied from high melioidosis titer. The prevalence was estimated as being from 0.49 to 1.02%. Most patients had underlying diseases (14, 88%), of which diabetes mellitus was the most prevalent (12, 75%). Nine cases (56%) were part of disseminated septicemia. Patients suffered from blindness in 11 (73%) of the 15 cases in which visual acuity was recorded. Orbital cellulitis was the most common manifestation (7, 44%) followed by endophthalmitis (4, 25%). Interestingly, all patients with necrotizing fasciitis (100%) developed septic shock as a consequence. In most of the cases, patients underwent surgery (13, 81%) including incision and drainage, debridement, and pars plana vitrectomy. Despite appropriate management, the visual outcomes were disappointing (9, 64%).

Conclusion: To summarize, ocular melioidosis is a highly destructive disease. Early detection and prompt surgical management may reduce morbidity and mortality from septic shock.

Keywords: Melioidosis, Burkholderia pseudomallei, Glanders, Orbital cellulitis, Endophthalmitis

Background
Melioidosis is caused by a gram-negative, motile, non-spore forming facultative anaerobic bacillus known as Burkholderia pseudomallei. The organism is found in soil and surface water and is widely distributed in Southeast Asia, especially in northeast Thailand and northern Australia [1].

Melioidosis presents with broad spectrums of clinical presentations and organ involvement. However, there are few case reports of ocular involvement in melioidosis, and most of these are single-case report or small case series.

In northeast Thailand, there are around 2000 culture-positive melioidosis cases per year [2]. Khon Kaen, one of the largest cities in northeast Thailand, has been called “the capital of melioidosis” due to the high prevalence of the disease in the region. Ocular involvement in these cases has not been investigated. The primary objective of this study was to estimate the prevalence and investigate ocular manifestations of melioidosis in Khon Kaen. Management and visual outcomes in these patients were also reviewed.

Results
We identified 16 cases of ocular involvement, 13 out of the 1270 melioidosis cases admitted to Srinagarind Hospital (prevalence 1.02%; 95% confidence interval from 0.49 to 1.02%).

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0.58 to 1.76%) and three out of the 607 admitted cases at Khon Kaen Hospital (prevalence 0.49%; 95% confidence interval from 0.10 to 1.51%). Overall, the estimated prevalence of ocular involvement in cases of melioidosis was from 0.49 to 1.02% (Table 1).

Of those 16 cases, there were 8 positive cultures. In the remaining eight cases, melioidosis was implied from the high titer for melioidosis in the bloodstream. Clinical descriptions of all cases are summarized in Table 2.

Baseline characteristics of the patients were comparable to general melioidosis patients. The male to female ratio was 3 to 1 with a median age of 50.5 years old (39–70). The most common occupation was farmer (nine cases, 56%). Most patients had underlying diseases (14 cases, 88%), of which diabetes mellitus was the most common (12 cases, 75%). Ocular involvement was part of dissemination in nine cases (56%), which were classified as disseminated septicemic melioidosis.

The majority of ocular melioidosis patients (10 cases, 63%) presented with eye symptoms. Interestingly, the other six cases initially presented with fever or a headache. Out of the 15 cases for which there were records of visual acuity, 11 (73%) presented with blindness. The ocular manifestations of melioidosis were classified as orbital cellulitis (seven cases, 44%), preseptal cellulitis (two cases, 13%), endophthalmitis (four cases, 25%), panophthalmitis (two cases, 13%), and panuveitis (one case, 6%).

In most cases, the definitive management was surgery (13 cases, 81%) including incision and drainage, debridement (eight cases, 62%), pars plana vitrectomy (three cases, 23%), and enucleation (two, 15%). There were only three cases (19%) in which the patients were able to be treated without surgery.

Despite adequate surgical intervention, the visual outcomes of ocular melioidosis were disappointing. Out of the 14 cases for which there were records of final visual acuity, nine (64%) patients ended up legally blind. Three of these patients (20%) presented with no light perception at the beginning, two had to be enucleated, two (14%) were stable, and two (14%) had progressive loss of vision. Patients had improved vision after treatment in only five cases (36%).

Discussion
To our knowledge, this is the first and largest case series of ocular involvement in melioidosis. A comprehensive literature review revealed only 14 cases from 12 reports [3–14], including 7 cases of orbital cellulitis (50%), 3 cases of endophthalmitis (21%), 3 cases of corneal ulcer (21%), and 1 case of acute dacryocystitis (7%). Most of the reports were single-case reports, and the largest one had only three cases.

In Thailand, especially in the northeast, there has been an increase in the reported cases of melioidosis. This is likely due to increasing awareness of the condition and increased sensitivity of the technology used to detect the organism. The mortality rate in these areas is around 40%. It is the third highest cause of mortality after acquired immune deficiency syndrome and tuberculosis [2]. Although ocular involvement in melioidosis is rare, the effects on patients’ vision are devastating. Most patients with this condition ended up becoming legally blind. In our series of 16 cases, there were only 5 (36%) in which patients had improved vision after treatment.

We suspect that the number of ocular melioidosis cases might be underestimated. Most of the melioidosis patients admitted to the hospital had disseminated septicemic melioidosis and were treated for life-threatening symptoms. Mild ocular symptoms might be easily overlooked, and ophthalmologists were not consulted in all cases.

The prevalence of ocular melioidosis in Srinagarind Hospital (1.02%) was about twice that in Khon Kaen Hospital (0.49%). The discrepancy might be due to the differences between the two hospitals. Srinagarind Hospital is the largest university hospital in northeast Thailand, and many severe cases of systemic melioidosis are referred to Srinagarind Hospital. Since more organs are affected in severe disseminated melioidosis, ocular involvement is more likely in these cases.

We suspect that the recent prevalence of ocular melioidosis in Srinagarind Hospital might be much higher than what we have found. From 2007 to April 2016, there were 264 cases of melioidosis at Srinagarind Hospital, of which 13 had ocular involvement. According to this finding, the prevalence during this time interval was as high as 4.9% (95% confidence interval from 2.82 to 8.32%).

This study led to some interesting findings. Ten patients (63%) presented with eye symptoms, which later resulted in

Table 1  Data collection and prevalence (95%CI) calculation

| Tertiary hospital                | Srinagarind University Hospital | Khon Kaen Provincial Hospital | Total from all data | Total from 2012 to 2016 |
|---------------------------------|--------------------------------|-------------------------------|--------------------|------------------------|
| Date                            | January 1993 to April 2016     | January 2012 to April 2016   | January 1993 to April 2016 | January 2012 to April 2016 |
| Length                          | 23 years and 4 months          | 4 years and 4 months         | 23 years and 4 months | 4 years and 4 months |
| Total melioidosis (cases)       | 1270                          | 607                           | 1877                | 859                    |
| Total ocular involvement (cases)| 13                            | 3                             | 16                  | 8                      |
| Prevalence (95% CI)             | 1.02% (0.58, 1.76%)            | 0.49% (0.10, 0.51%)          | 0.85% (0.51, 1.39%)  | 0.93% (0.44, 1.86%)    |
| Year | Age | Sex | Occupation | Symptom | Laterality | Initial VA | Ocular positive finding | Ocular diagnosis | Risk factor | Type of melioidosis | Primary organ symptoms | Investigations | Treatments | Outcomes |
|------|-----|-----|------------|---------|------------|------------|-------------------------|-----------------|-------------|------------------|------------------------|---------------|------------|---------|
| 2007 | 70  | F   | None       | Progressive painful proptosis with fever 10 days, S/P IV clindamycin at provincial hospital (onset = 10 days) | OD | No LP | Complete ptosis, marked eyelid swelling, IOP 21/13, marked chemosis, clear cornea, no C/F, positive RAPD, EOM 0% all direction, pale disc with choroidal fold | Orbital cellulitis | History of eye scratching with dirty hand | Disseminated | Eye | Acute sphenoidal sinusitis, meningitis, septic arthritis, melioidosis septicemia | Hemoculture: B. pseudomallei, LP: eosinophilic meningitis, MRI orbit right orbital cellulitis with extrascleral abscess latero-superior aspect | FESS, I&D, IV ceftazidime then oral bactrim, tarsorrhaphy | VA no LP, limit EOM 90% at lateral gaze OD, other EOM are full, normal anterior segment, pale disc, attenuated vessel (No LP at initial) |
| 2007 | 64  | M   | Farmer     | Progressive proptosis 10 days, PTA, S/P IV ceftazidime, IV clindamycin at provincial hospital (onset = 10 days) | OS | CF 2 ft | Lid swelling, proptosis, chemosis, clear cornea, no C/F, positive RAPD, EOM 0% all direction | Orbital cellulitis | DM without DR, CKD | Disseminated | Eye | Pansinusitis, subcutaneous abscess at inferolateral of the eye | Hemoculture: B. pseudomallei, pus culture: B. pseudomallei, CT orbit: pansinusitis with severe orbital cellulitis | I&D, FESS, IV ceftazidime then oral bactrim, topical antibiotic | VA 6/24, VA with pinhole 6/12, less chemosis, less proptosis, normal anterior segment, EOM limit at downgaze (improve) |
| 2008 | 61  | M   | Farmer     | Progressive painful visual loss 2 weeks | OS | No LP | Generalized bedewing cornea, hypopyon 2-mm, shallow AC, IOP 3+/2+, positive RAPD, EOM 50% all direction, B scan: generalized vitreous opacity, intra-op findings: dense vitreous abscess, subretinal abscess rupture to vitreous | Panophthalmitis | DM without DR, CKD | Localized | Eye | Hemoculture: no growth, melioid titer 1:122, CT orbit: swelling of periorbital tissue | Hemoculture: PPV, ECCE, topical vancomycin, topical ceftazidime, oral bactrim | VA no LP, conjunctival lesions chemosis, AC deep with plasmoid and hyphema no record about posterior segment (No LP at initial) |
| Year | Age | Sex | Occupation | Symptom | Laterality | Initial VA | Ocular positive finding | Risk factor | Associated symptoms | Type of melioidosis | Primary organ | Associated symptoms | Investigations | Treatments | Outcomes |
|------|-----|-----|------------|---------|------------|------------|------------------------|-------------|---------------------|-----------------|----------------|---------------------|--------------|------------|---------|
| 2008 | 51  | F   | Teacher    | Fever with dyspnea | PTA, left eye inflammation | OS | HM, good PJ | Corneal bedewing, C/F 4+/4+, positive RRAPD, intraop findings: attenuated vessels, subretinal gliosis, shallow RD | DM without DR | Pulmonary edema | Endogenous endophthalmitis | Hemoculture: no growth, melioid titer 1:5122, MRI orbit: preseptal cellulitis | PPV with silicone oil, ECCE, IV ceftazidime then oral bactrim, topical vancomycin, topical ceftazidime | VA HM poor PJ, AC deep with plasmoid, attach retina (onset = NA) (stable) |
| 2009 | 39  | F   | Farmer     | Eye pain with fever | OD 6/24 | Marked eyelid swelling and erythema, fluctuation, no discharge, clear cornea, no C/F, negative RAPD, normal posterior segment | Preseptal cellulitis | DM without DR | Multifocal Eye | Pneumonia, no growth, melioid titer 1/640, pus culture: B. pseudomallei, melioid titer 1/640, hemoculture: NG, CT orbit: preseptal cellulitis | I&D upper eyelid, I&D right thigh, oral bactrim | VA 6/9, VA with pinhole from +1.5 (onset = 2 weeks) (improve) |
| 2011 | 46  | M   | Labor      | Fever with constitutional symptoms | OS CF 2 ft | Conjunctival chemosis, corneal stromal edema, hypopyon, hyphema, C/F 4+/2+, retinal infiltration | Endogenous endophthalmitis | DM without DR | Multifocal Eye | Hemoculture: no growth, melioid titer 1:5122, CT abdomen: multiple liver abscesses, splenic abscess | IV ceftazidime then oral bactrim | VA 3/60, VA with pinhole from +1.5 (onset = 3 days) (improve) |
| 2011 | 43  | F   | Farmer     | Painful proptosis | OS Not done due to alteration of consciousness | Necrotizing fasciitis at left upper eyelid, size 1 × 8 cm, purulent discharge, ciliary injection, clear cornea, no C/F, clear vitreous | Orbital cellulitis, necrotizing fasciitis | First dx DM without DR | Disseminated Eye | Hemoculture: B. pseudomallei, pus culture: B. pseudomallei, CT orbit: orbital abscess at the superomedial wall of orbit, subcutaneous abscess at neck, renal meloidosis, mental muscle, lateral rectus muscle | Hemoculture: B. pseudomallei, pus culture: B. pseudomallei, CT orbit: orbital abscess at the superomedial wall of orbit, subcutaneous abscess at neck, renal meloidosis, mental muscle, lateral rectus muscle | Debridement of necrotic wound, IV ceftazidime then oral bactrim | Good wound, less swelling, no record about VA (onset = 8 days) (NA) |
| 2011 | 46  | M   | Labor      | Painless visual loss | OS LP, poor PJ | IOP 32, bedewing cornea, hypopyon with plasmoid in | Endogenous endophthalmitis | DM without DR | Multifocal Eye | Hemoculture: NG, melioid titer 1:640 | PPV with silicone oil, oral bactrim | VA no LP, pain-aided discharge (onset = 1 week) | Painful red eye 1 week after discharge, VA no LP, pain-aided discharge (onset = 1 week) | Liver abscesses, single abscess | Hemoculture: B. pseudomallei, pus culture: B. pseudomallei, CT orbit: orbital abscess at the superomedial wall of orbit, subcutaneous abscess at neck, renal meloidosis, mental muscle, lateral rectus muscle | Liver abscesses, single abscess | (NA) | (improve) |

Note: Table 2: Clinical descriptions of all cases (Continued)
| Year | Age  | Sex | Occupation | Symptom | Laterality | Initial VA | Ocular positive finding | Ocular diagnosis | Risk factor | Type of melioidosis | Primary organ | Associated symptoms | Investigations | Treatments | Outcomes |
|------|------|-----|------------|---------|-----------|------------|------------------------|-----------------|------------|----------------------|--------------|---------------------|--------------|------------|---------|
| 2012 | 63   | M   | Farmer     | Painful proptosis 2 weeks | OD       | 20/200     | Marked eyelid swelling, no discharge, conjunctival injection, keratic precipitates at the cornea, peripheral synechiae 360 degrees, CF 4+/2+, vitreous opacity grade 4 | Panuveitis, preseptal cellulitis | MDS, leukemia | Disseminated | Eye | Spondylodiscitis, epidural and paravertebral abscess | Hemoculture: no growth, melioid titer 1: 5120 | IV ceftazidime, 1% prednisolone acetate eye drop RE qid | VA 20/200, peripheral synechiae 360 degrees, vitreous opacity grade 1 | (stable) |
| 2012 | 54   | M   | Farmer     | Fever with left side headache 1 week PTA then left facial edema 5 days PTA then painful proptosis 3 days | OS       | No LP      | Marked eyelid swelling, erythema and tender, copious pus and discharge, marked chemosis, clear cornea, no CF, positive RAPD, B scan vitreous opacity, intra-op finding: pus 1 ml in the vitreous cavity, flame shape hemorrhage, disc swelling, venous congestion, drusen | Orbital cellulitis | DM without DR | Disseminated | Maxillary sinus | Maxillary sinusitis, melioidosis septicemia | Hemoculture: B. pseudomallei, pus culture B. pseudomallei, CT orbit maxillary sinuses | I&D, orbital decompression, IV ceftazidime then oral bactrim | VA no LP, less swelling periorbital area, conjunctival chemosis, normal anterior segment, limit EOM all direction, fundus disc swelling, flame shape hemorrhage (No LP at initial) |
| 2012 | 65   | M   | Housekeeper | Fever with chill 3 days | OD       | 6/6        | Upper eyelid swelling, Preseptal cellulitis | DM without DR | Disseminated | Hematogenous – | – | – | – | VA 6/6, no lid swelling, |

(continuation...)
| Year | Age | Sex | Occupation | Symptom | Laterality | Initial VA | Ocular positive finding | Ocular diagnosis | Risk factor | Type of melioidosis | Primary organ | Associated symptoms | Investigations | Treatments | Outcomes |
|------|-----|-----|------------|---------|------------|------------|-------------------------|-----------------|------------|---------------------|--------------|-------------------|--------------|------------|---------|
| 2013 | 57  | M   | Thai massager | Pain at the left temporal area | OS | 20/200 | Proptosis, chemosis, clear cornea, no C/F, negative RAPD, EOM | Orbital cellulitis | DM without DR | Localized temporal space abscess | Temporal space abscess, subperiosteal abscess | Pus culture: B. pseudomallei, hemoculture: NG, CT orbit: left panophthalmitis with subperiosteal abscess | I&D temporal space abscess, lateral and medial orbitotomy, I&D orbital abscess, IV ceftazidime then oral bacitracin | VA 6/9, no sign of inflammation, residual ptosis, normal anterior segment, no record about posterior segment | (improve) |
| 2014 | 42  | M   | Farmer | Right eye contact with wood particle | OD | HM at provincial hospital then no LP | Multiple keratic precipitates at the cornea, CF 4+4+, positive RAPD, vitreous opacity grade 4, B scantiloculated vitreous haze, membrane-like lesion attach to disc, moderate to high spike, intra-op finding: yellow pus with blood clot | Endogenous endophthalmitis | OD, chronic alcoholism, wood particle contact, breast milk instillation | Multifocal Eye | Scleral abscess | Gram stain from pus: gram-negative rod safety pin, pus culture: no growth, hemoculture: no growth, melioid titer 1:122, ultrasound abdomen: scleral abscess | Enucleation, IV ceftazidime then oral bacitracin | Good enucleation wound | (enucleated) |
| 2014 | 45  | M   | Officer | Proptosis 4 days PTA, S/P FESS, orbital decompression at private hospital | OS | CF | Marked eyelid swelling, fluctuation, chemosis, limit EOM at upper and lateral gaze | Orbital cellulitis | DM without DR | Multifocal Sinus | Abscess at right leg | Pus culture from the eye: B. pseudomallei, pus culture from the right leg: B. pseudomallei | I&D, IV ceftazidime then oral bacitracin | Less swelling, less chemosis, normal anterior segment, | | | |
| Year | Age | Sex | Occupation | Symptom | Laterality | Initial VA | Ocular positive finding | Ocular diagnosis | Risk factor | Type of melioidosis | Primary organ | Associated symptoms | Investigations | Treatments | Outcomes |
|------|-----|-----|------------|---------|------------|------------|-------------------------|----------------|------------|-------------------|--------------|-------------------|--------------|------------|---------|
| 2015 | 50  | M   | Farmer     | Low-grade fever 2 weeks PTA, right eye pain 9 days PTA, painful proptosis with visual loss 7 days PTA, S/P IV ceftriaxone IV metronidazole at provincial hospital, progressive proptosis in this admission | OD | HM | Proptosis, marked chemosis, AC deep with C/F 4+/3+, positive RAPD, peripheral synechiae, vitreous opacity grade 4, EOM minimal limit all direction, B scan: vitreous opacity, subretinal abscess, intra-op finding: yellow pus 0.2 ml | Panophthalmitis | – | Disseminated | Hematogenous | Liver abscess, ethmoid sinusitis | Hemoculture: no growth, melioid titer 1:5122, vitreous culture no growth | PPV, IV ceftriaxone | I&D, FESS, skin debridement, IV adefovir | (worse) |
| 2015 | 45  | M   | Farmer     | Painful proptosis with fever 2 weeks, S/P IV antibiotic at primary care hospital | OD | 1/60 at primary care hospital then LP | Marked eyelid and periorbital area swelling vesicle at medial canthus, marked bloody chemosis, dear cornea, no C/F, positive RAPD, EOM 0% all direction, necrotic skin at forehead 2 x 3 cm | Orbital cellulitis, Necrotizing fasciitis | DM without DR, psoriasis, chronic alcoholism | Disseminated | Eye | Sinusitis, septic arthritis, splenic abscess, septic shock | Hemoculture: B. pseudomallei x II, pus culture from the eye: B. pseudomallei, pus culture from the right knee: B. pseudomallei | I&D, FESS, skin debridement, IV adefovir | VA no LP, normal globe contour, no record about anterior and posterior segment | (worse) |
systemic spreading. On the other hand, there were six patients (38%) whose first symptoms were not eye symptoms; four patients (25%) presented with fever and two (13%) presented with a headache. In most cases, diabetes mellitus was the underlying disease (12 cases, 75%), but none of the patients in those cases had diabetic retinopathy.

Interestingly, we found that most cases of ocular melioidosis were classified as disseminated septicemic melioidosis (nine cases, 56%) which means that there was a bloodstream infection. This is unlike other gram-positive organisms, which usually cause orbital cellulitis and commonly result in a negative hemoculture. The explanation for this finding may be attributable to the nature of *Burkholderia pseudomallei* infection, which generally presents with bloodstream infection.

In our study, orbital cellulitis was the most common manifestation (seven cases, 44%). Usually, orbital cellulitis is caused by gram-positive organisms and can be cured only by intravenous antibiotics, unlike orbital cellulitis caused by melioidosis. All of these patients ended up undergoing surgical intervention (100%). The abscess-forming activity of *Burkholderia pseudomallei* may be the reason why intravenous antibiotics alone did not work to treat the condition.

Moreover, there were two cases (29%) of orbital cellulitis that progressed to necrotizing fasciitis, which is uncommon in other types of bacterial orbital cellulitis. This is similar to the results of a previous case report by Saonanon P [13]. Unfortunately, all of our patients (100%) with necrotizing fasciitis subsequently developed septic shock. Early suspicion and prompt surgical debridement may improve mortality in these patients.

We also found that even if systemic ceftazidime was used, the occurrence of endogenous endophthalmitis caused by melioidosis was not preventable, as stated in a previous report [10]. Most of the cases diagnosed as endophthalmitis and panophthalmitis required surgical intervention (five out of six cases, 83%), including pars plana vitrectomy (three out of five cases, 60%) and enucleation (two out of five cases, 40%).

Two cases (50%) of endophthalmitis were enucleated. The first case, from 2011, had a delayed presentation. The patient had experienced loss of vision for 1 month prior to admission, which was the longest onset in any of the cases. In the second case, from 2014, the patient exhibited two risk factors for the condition, including wood particle contact and breast milk instillation into the eye, as a result of local traditional treatment practices.

There were three cases that were cured without any surgical intervention. In one case, this was due to the patient seeking early treatment for endogenous endophthalmitis. The other two patients had diagnoses that did not require an operation (namely, panuveitis and preseptal cellulitis).

**Conclusions**

In summary, ocular involvement in melioidosis was rare, but the outcomes were devastating. The most common ocular involvements were orbital cellulitis and endophthalmitis. The morbidity in these cases was high, so it is critical to employ a high index of suspicion. Ocular melioidosis should be considered when the ocular infection does not respond to conventional antibiotic therapy, especially in hyperendemic regions for melioidosis. Early consultation with an ophthalmologist and prompt surgical intervention may significantly improve the final visual outcomes, as well as mortality rates.

**Methods**

We retrospectively reviewed all admitted cases of melioidosis with ocular involvement from two tertiary hospitals in Khon Kaen using electronic databases. The first is Srinagarind Hospital, which is a university hospital. We searched the hospital’s electronic database for cases of this condition from January 1993 to April 2016 (23 years and 4 months). The second is Khon Kaen Hospital, which is a provincial hospital. We searched the hospital’s electronic database for cases that presented between January 2012 and April 2016 (4 years and 4 months). The data were retrieved using the ICD10 code for melioidosis (all A24 codes) and all diseases of the eye and adnexa (code H00 to H59).

This manuscript adheres to the guidelines and principles laid out in the Declaration of Helsinki. Institutional review board (IRB) approval was obtained from the Khon Kaen University and Khon Kaen Hospital, Thailand. The clinical trial was registered in Thai Clinical Trials Registry (study ID: TCTR20160818004).

We only included cases in which there were positive cultures for melioidosis or high blood titer according to indirect hemagglutination (IHA). The cutoff point for positive antibody titers has been determined to be 1:160 in endemic areas [15]. Irrelevant ocular diagnoses, such as cataracts, glaucoma, diabetic retinopathy, or other underlying eye diseases, were excluded. The prevalence and 95% confidence intervals (95% CI) were calculated using the modified Wald method. Other results were summarized as proportions and percentages.

**Abbreviations**

AC: Anterior chamber; B. pseudomallei: *Burkholderia pseudomallei*; C/F: Cell/flare; CF: Counting fingers; CKD: Chronic kidney disease; DM: Diabetes mellitus; DR: Diabetic retinopathy; ECCE: Extracapsular cataract extraction; EOM: Extraocular movement; F: Female; FESS: Functional endoscopic sinus surgery; HM: Hand motion; I&D: Incision and drainage; IOP: Intraocular pressure; LP: Light perception; LP: Lumbar puncture; M: Male; MDS: Myelodysplastic syndrome; MR: Magnetic resonance imaging; NA: Not available; OD: Right eye; OS: Left eye; PJ: Light projection; PPV: Pars plana vitrectomy; RAPD: Relative afferent pupil defect; RD: Retinal detachment; RRAPD: Reverse relative afferent pupil defect; VA: Visual acuity
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Authors’ contributions
SY carried out the ophthalmology studies, participated in the research design, participated in the data acquisition at the university hospital, participated in the data interpretation, and drafted the manuscript. SA carried out the ophthalmology practices, participated in the research design, participated in the statistical analysis, and helped to draft the manuscript. PC carried out the infectious practices, provided expertise regarding melioidosis, participated in the research design, helped facilitate the coordination between two hospitals in the study, and drafted the manuscript. SW carried out the microbiological studies, provided expertise with regard to melioidosis, participated in the data acquisition and coordination between departments, and helped to draft the manuscript. PP carried out the ophthalmology practices at the provincial hospital and participated in the data acquisition at the provincial hospital. All authors read and approved the final manuscript.

Ethics approval and consent to participate
The manuscript adheres to the guidelines and principles by the Declaration of Helsinki. Institutional review board (IRB) approval was obtained from Khon Kaen University, Thailand, numbered HE581497 and Khon Kaen Hospital, Thailand, numbered KES9045. The clinical trial was registered in Thai Clinical Trials Registry study ID: TCTR20160818004.

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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