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Closure of medical departments during nosocomial outbreaks: data from a systematic analysis of the literature

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Summary A total closure of an affected medical department is one of the most expensive infection control measures during investigation of a nosocomial outbreak. However, until now there has been no systematic analysis of typical characteristics of outbreaks, for which closure was considered necessary. This article presents data on features of such nosocomial epidemics published during the past 40 years in the medical literature. A search of the Outbreak Database (1561 nosocomial outbreaks in file) revealed a total of 194 outbreaks that ended up with some kind of closure of the unit (median closure time: 14 days). Closure rates (CRs) were calculated and stratified for medical departments, for causative pathogens, for outbreak sources, and for the assumed mode of transmission. Data were then compared to the overall average CR of 12.4% in the entire database. Wards in geriatric patient care were closed significantly more frequently (CR: 30.3%; \( P < 0.001 \)) whereas paediatric wards showed a significantly lower CR (6.1%; \( P = 0.03 \)). Pathogen species with the highest CR were norovirus (44.1%; \( P < 0.001 \)) and influenza/parainfluenza virus (38.5%; \( P < 0.001 \)). If patients were the source of the outbreak, the CR was significantly increased (16.7%; \( P = 0.03 \)). Infections of the central nervous system were most often associated with closure of the ward (24.2%; \( P = 0.01 \)). A systematic evaluation of nosocomial outbreaks can be a valuable tool for education of staff in the absence of an outbreak, but may...
Introduction

Although most nosocomial infections occur endemically, still outbreaks may cause tremendous problems for health care systems.\(^1,^2\) The consequences of such nosocomial outbreaks may affect the individual patient, the medical department, or even the entire hospital: (1) Affected patients may suffer from possible infections due to the outbreak strain. The morbidity and the risk of mortality may increase. Additional antimicrobial treatment can become necessary and the duration of hospital stay may be prolonged.\(^3\) (2) On the affected ward, the recognition of an outbreak often causes uncertainty about the outbreak’s origin, the transmission route, and about appropriate infection control measures required to bring the outbreak to an end. Furthermore, almost every nosocomial outbreak will increase the costs for the affected medical department especially when a total closure of the unit is considered. That is why a total closure is performed only if all previous infection control measures have failed to control the pathogen’s spread. This closure of the unit may comprise the immediate cessation of new admissions to the ward until disinfection of the ward has been carried out, but it may also include temporary cancellation of scheduled surgical operations or restriction of certain diagnostic procedures.\(^4,^6\) Sometimes the extent of a closure may vary within the course of one single outbreak.\(^7\) (3) Publication of a nosocomial outbreak in public media may represent a threat for the reputation of the entire healthcare facility.

Even after the successful termination of the outbreak following the closure of the ward, the contribution of this specific infection control measure remains unknown. Until now, there has been no systematic analysis of outbreak descriptions in the medical literature with respect to the impact of restrictions on new admissions on the affected ward. This information could be very valuable when such an expensive measure is considered in an outbreak situation. This systematic review provides an overview on nosocomial outbreaks published in 40 years of medical literature.

Methods

Data acquisition

Collection of outbreak descriptions was performed by a search of the 'Outbreak Database' (http://www.outbreak-database.com) in August 2005. This database is freely assessable via the internet and contains detailed descriptions of numerous nosocomial outbreaks. All of these outbreaks are filed in a systematic manner that allows the user a quick and convenient query for the parameter of interest (e.g. causative pathogen, number of affected patients, or implemented infection control measures). The development of the database has been described in more detail elsewhere.\(^8\) Meanwhile, this database includes approximately 75% of all nosocomial outbreaks ever published in PubMed. There were no restrictions with respect to a minimum number of patients involved in the outbreak, to the type of publication (editorial, letter, case report, or original article), or to language.

Definition of ‘closure of the unit’

An intervention considered as a ‘closure’ was defined as any partial or total closure of an affected location, regardless of its duration or complexity.

Data extraction

For all outbreaks in which ‘closure’ was applied, the following data were obtained: (a) the type of medical department; (b) the degree of closure, e.g. part of the unit, the entire unit, or multiple units; (c) the species of the nosocomial pathogen; (d) the most probable source of the outbreak; (e) the route of transmission; (f) the distribution of outbreak-associated nosocomial infections.

Data analysis

Closure rates (CRs) were calculated stratified by each of the parameters listed above. The CR of each stratified parameter was then compared
to the average CR in the whole database using Fisher’s exact test \( (P < 0.05) \) using EpInfo® 3.3.2 software.

**Results**

Overall there were 1561 outbreaks filed in the Outbreak Database, in 194 of which some kind of closure had been performed as an infection control measure. The exact duration of closure was described in 32 outbreaks. In these outbreaks the median closure time was 14 days (range: 3–56 days).

The distribution of the main affected medical departments and corresponding CR are shown in Table I in more detail. Highest CRs were reported from geriatric patient care (30.3%), and from orthopaedic departments (22.5%). Table II shows the CR with respect to different nosocomial pathogens. Viral infections especially, such as norovirus (44.1%) and influenza/parainfluenza virus (38.5%), were associated with closure of the unit.

Only 135 of the 194 analysed outbreaks provided detailed information on the degree of closure in the particular outbreak setting. In the vast majority (94 of 135 outbreaks; 69.6%), the entire unit was closed during the epidemic. Entire facilities had been closed in outbreaks due to influenza virus (three outbreaks), SARS coronavirus (two), *S. pneumoniae* (two), norovirus (one), *Shigella* spp. (one), and rotavirus (one).

Besides closure of the ward, several additional infection control measures were described. The most frequent interventions were isolation of infected or colonized patients (66.0%), screening cultures and surveillance of patients (58.0%) and staff (49.5%), as well as enforced hand hygiene (43.3%) and reprocessing of devices (sterilization or disinfection; 43.3%). Other less common infection control measures comprised education of healthcare workers (24.2%), restriction of the work load (16.5%), or vaccination if available (4.7%), e.g. for the prevention of infection by hepatitis B virus or by *S. pneumoniae*.

Tables III–V summarize the data on the source of the outbreak, the mode of pathogen transmission, and the distribution of nosocomial infections that finally led to closure of the ward. CR was high especially when patients had been the source of the outbreak (16.7%; Table III) and when the pathogen had been acquired by inhalation or by contact (18.7 and 16.5% respectively; Table IV). The highest CR were recorded when infection of the central nervous system (24.2%) or infections of eye, ear, nose, throat or mouth (22.0%) occurred (Table V). Apart from these two classes of infection, there was no significant difference between the average CR (12.4%) and that of any other class.

**Discussion**

As stated before, a total closure of a medical department is an extremely cost-intensive measure in a nosocomial outbreak setting. However, outbreak management is always a multi-task procedure

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**Table I** Closure rates in outbreaks stratified by the medical department (Outbreak Database, \( N = 1561 \))

| Medical departmenta | Total no. of outbreaksb | Outbreaks including some kind of closure | Closure rate | \( P\)-value |
|---------------------|------------------------|----------------------------------------|-------------|-------------|
| General surgery     | 346                    | 44                                     | 12.7%       | NS          |
| Neonatology         | 332                    | 53                                     | 16.0%       | NS          |
| Internal medicine   | 307                    | 44                                     | 14.3%       | NS          |
| Paediatrics         | 132                    | 8                                      | 6.1%        | 0.03        |
| Haematology/oncology| 125                    | 12                                     | 9.6%        | NS          |
| Geriatrics          | 79                     | 24                                     | 30.3%       | \(<0.001\)  |
| General medicine    | 76                     | 3                                      | 3.9%        | 0.03        |
| Haemodialysis       | 76                     | 5                                      | 6.6%        | NS          |
| Neurology/psychiatry| 66                     | 7                                      | 10.6%       | NS          |
| Gynaecology/obstetrics| 58                   | 10                                     | 17.2%       | NS          |
| Transplantation units| 56                    | 5                                      | 8.9%        | NS          |
| Orthopaedics        | 40                     | 9                                      | 22.5%       | NS          |
| Neurosurgery        | 39                     | 9                                      | 17.9%       | 0.05        |
| Urology             | 38                     | 5                                      | 13.2%       | NS          |
| Total               | 1561                   | 194                                    | 12.4%       | –           |

NS, not significant.
a Only medical departments in which at least 20 outbreaks had been reported are included.
b Multiple answers possible.
and the exact costs for the closure are difficult
to determine. In a retrospective cost analysis of a
four-month outbreak caused by extended-spectrum
beta-lactamase-producing (ESBL) K. pneumoniae
in a neonatal intensive care unit, approximately one-
third of the total outbreak costs could be referred
to the lost revenue from blocked patient beds.9 To
avoid unnecessary expenses during an outbreak it
is important to implement evidence-based and ef-
fective infection control recommendations to limit
pathogen spread at the earliest possible stage.

Knowledge of certain characteristics that will lead
to closure of the unit in a large proportion of out-
breaks may be useful when deciding whether to
close the ward at an earlier time point.

Our analysis demonstrates that such an expen-
sive measure is likely to be necessary in viral
infections of the gastrointestinal (norovirus) or
respiratory (influenza/parainfluenza) tract (Table II).
This may reflect the high transmissibility and low
infectious dose of these pathogens.10,11 In addi-
tion, prolonged survival time of the outbreak strain

| Table II | Closure rates in outbreaks stratified by the causative pathogen (Outbreak Database, N = 1561) |
|----------|--------------------------------------------------------------------------------------------------|
| Speciesa | Total no. of outbreaksb | Outbreaks including some kind of closure | Closure rate | P-value |
|----------|-------------------------|------------------------------------------|--------------|---------|
| S. aureus | 223                     | 23                                       | 10.3%        | NS      |
| Hepatitis virus | 150                     | 6                                        | 4.0%         | 0.002   |
| Pseudomonas spp. | 130                     | 10                                      | 7.7%         | NS      |
| Klebsiella spp. | 115                     | 10                                      | 8.7%         | NS      |
| Acinetobacter spp. | 105                     | 24                                      | 22.9%        | 0.02    |
| Serratia spp. | 94                      | 14                                      | 14.9%        | NS      |
| Enterococci | 67                      | 8                                        | 11.9%        | NS      |
| Enterobacter spp. | 66                      | 10                                      | 15.2%        | NS      |
| Streptococci | 63                      | 18                                      | 28.6%        | 0.001   |
| Salmonella spp. | 56                      | 4                                        | 7.1%         | NS      |
| Legionella spp. | 48                      | 2                                        | 4.2%         | NS      |
| Norovirus | 34                      | 15                                       | 44.1%        | <0.001  |
| Clostridium spp. | 34                      | 4                                        | 11.8%        | NS      |
| Aspergillus spp. | 25                      | 5                                        | 20.0%        | NS      |
| Influenza/parainfluenza virus | 26                      | 10                                       | 38.5%        | <0.001  |
| Citrobacter spp. | 12                      | 3                                        | 25.0%        | NS      |
| Adenovirus | 11                      | 3                                        | 27.3%        | NS      |
| Shigella spp. | 11                      | 4                                        | 36.4%        | 0.04    |
| Rotavirus | 27                      | 7                                        | 25.9%        | 0.05    |
| SARS coronavirus | 12                      | 4                                        | 33.3%        | NS      |
| Total | 1561 | 194 | 12.4% |

SARS, severe acute respiratory syndrome; NS, not significant.
a Only pathogens that had been reported in at least 10 outbreaks are included.
b Multiple answers possible.

Table III | Closure rates in outbreaks stratified by the source of the outbreak (Outbreak Database, N = 1561) |
|----------|--------------------------------------------------------------------------------------------------|
| Source | Total no. of outbreaksa | Outbreaks including some kind of closure | Closure rate | P-value |
|----------|-------------------------|------------------------------------------|--------------|---------|
| Patient | 395                     | 66                                       | 16.7%        | 0.03    |
| Environment | 194                     | 24                                       | 12.4%        | NS      |
| Medical devices | 172                     | 12                                       | 7.0%         | 0.04    |
| Personnel | 154                     | 17                                       | 11.0%        | NS      |
| Drugs | 73                      | 3                                        | 4.1%         | 0.03    |
| Food | 50                      | 1                                        | 2.0%         | 0.03    |
| Equipment for patient care | 35                      | 5                                        | 14.3%        | NS      |
| Source not known | 518                     | 80                                       | 13.8%        | NS      |
| Total | 1561 | 194 | 12.4% |

NS, not significant.
a Multiple answers possible.
in the environment may contribute to the likelihood of transmission, as it has been proposed in outbreaks due to *Acinetobacter* spp.\textsuperscript{12}

Closure of a department is usually considered much more often when it cares for older patients but less so on paediatric wards (Table I). This can easily be explained by the confounding fact that most norovirus outbreaks take place on geriatric wards. In geriatric patients, it is especially difficult to implement sufficient infection control measures such as isolation in private rooms, and also to achieve a high compliance with alcohol-based hand rub.\textsuperscript{13}

In terms of the outbreak’s source, we found that contaminated medical devices led significantly less often to the closure of the ward. Most probably these kinds of outbreaks stopped as soon as the device was identified as the source of the outbreak and were removed. By contrast, there was no such option for outbreaks in which infectious patients were responsible for the spread of the pathogen (Table III). A similar explanation might be applicable for the findings on transmission by contact vs an invasive technique (Table IV).

There are limitations to our analysis that must be borne in mind. (1) When performing a systematic analysis on medical literature, one has to rely on published data. However, most probably the majority of nosocomial outbreaks will not be published in the medical literature or will not even be recognized. Thus there will be some bias towards extraordinary species or towards common species that show a more antimicrobial-resistant phenotype. We believe that the large number of outbreaks filed already in the Outbreak Database balances this publication bias at least to some extent. (2) Some characteristics need a more detailed differentiation. For example, we cannot distinguish between the different kinds of hepatitis viruses, the various types of environmental source, or the sort of contact that occurred (direct or indirect by contaminated surfaces).

### Table IV
Closure rates in outbreaks stratified by the route of transmission (Outbreak Database, \(N = 1561\))

| Route of transmission          | Total no. of outbreaks\textsuperscript{a} | Outbreaks including some kind of closure | Closure rate | \(P\)-value |
|--------------------------------|-------------------------------------------|----------------------------------------|--------------|-------------|
| Contact                        | 752                                       | 124                                    | 16.5%        | 0.01        |
| Invasive techniques            | 273                                       | 13                                     | 4.8%         | 0.01        |
| Inhalation                     | 166                                       | 31                                     | 18.7%        | 0.02        |
| Ingestions                     | 63                                        | 4                                      | 6.3%         | NS          |
| Mode not known                 | 404                                       | 41                                     | 10.1%        | NS          |
| Total                          | 1561                                      | 194                                    | 12.4%        | —           |

\textsuperscript{a} Multiple answers possible.

### Table V
Closure rates in outbreaks stratified by the kind of infection (Outbreak Database, \(N = 1561\))

| Site of nosocomial infection\textsuperscript{a} | Total no. of outbreaks\textsuperscript{b} | Outbreaks including some kind of closure | Closure rate | \(P\)-value |
|-------------------------------------------------|-------------------------------------------|----------------------------------------|--------------|-------------|
| Blood stream infection                          | 589                                       | 76                                     | 12.9%        | NS          |
| Gastrointestinal tract                          | 402                                       | 49                                     | 12.2%        | NS          |
| Pneumonia                                       | 331                                       | 44                                     | 13.3%        | NS          |
| Surgical site infection                         | 195                                       | 21                                     | 10.7%        | NS          |
| Urinary tract                                   | 190                                       | 23                                     | 12.1%        | NS          |
| Skin and soft tissue                            | 171                                       | 21                                     | 12.3%        | NS          |
| Other lower respiratory tract                   | 134                                       | 21                                     | 15.7%        | NS          |
| Eye, ear, nose, throat, mouth                   | 109                                       | 24                                     | 22.0%        | 0.004       |
| Central nervous system                          | 95                                        | 23                                     | 24.2%        | 0.001       |
| Other systemic infection                        | 49                                        | 7                                      | 14.3%        | NS          |
| Bones and joints                                | 44                                        | 5                                      | 11.4%        | NS          |
| Cardiovascular system                           | 34                                        | 4                                      | 11.8%        | NS          |
| Total                                          | 1561                                      | 194                                    | 12.4%        | —           |

\textsuperscript{a} Only nosocomial infections that had been reported in at least 20 outbreaks are included.

\textsuperscript{b} Multiple answers possible.
More systematic analysis of nosocomial outbreaks needs to be performed to gain a better insight into the speciality of certain pathogens, possible sources of nosocomial outbreaks, and effective infection control measures. The Outbreak Database happens to be a very valuable tool for obtaining a quick overview on all kinds of outbreaks. It can therefore be used for education of staff to prevent the occurrence of an outbreak in the first place, but it may also be helpful when quick decisions need to be made during the investigation of a current epidemic.

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