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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%; $P = 001$). A systematic evaluation of nosocomial outbreaks can be a valuable tool for education of staff in the absence of an outbreak, but may

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be even more helpful for potentially cost-intensive decisions in the acute outbreak setting on the ward.

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 EpiInfo® 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

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

Medical department[a]	Total no. of outbreaks[b]	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.

Table II Closure rates in outbreaks stratified by the causative pathogen (Outbreak Database, $N = 1561$)

Species[a]	Total no. of outbreaks[b]	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.

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 effective 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 outbreaks may be useful when deciding whether to close the ward at an earlier time point.

Our analysis demonstrates that such an expensive 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 addition, prolonged survival time of the outbreak strain

Table III Closure rates in outbreaks stratified by the source of the outbreak (Outbreak Database, $N = 1561$)

Source	Total no. of outbreaks[a]	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.

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

Route of transmission	Total no. of outbreaks[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%	—

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.[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.[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 V Closure rates in outbreaks stratified by the kind of infection (Outbreak Database, $N = 1561$)

Site of nosocomial infection[a]	Total no. of outbreaks[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%	—

NS, not significant.
[a] Only nosocomial infections that had been reported in at least 20 outbreaks are included.
[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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