**Supplementary material**

**Table 1.** Key reporting variables and defining questions

| **Variables** | **Question** |
| --- | --- |
| Year | What was the year of the outbreak presentation? |
| Location | What was the country where the outbreak took place? |
| *B. cepacia* positives | What’s the number of patients with positive cultures for BC? |
| Samples | What’s the nature of the collected samples? |
| *B. cepacia* findings | Were the findings triggered by clinical signs or routine check-up based? |
| Bacteraemia | What’s the number of reported bactaeremias? |
| Sepsis | What’s the number of reported sepses? |
| Deaths | What’s the number of reported deaths?  |
| Hospital | What type of hospital did the outbreak take place (public/private)? |
| Centres involved  | Was the outbreak multicentre or single centre? |
| Level of care | What’s the level of care provided at the hospital (primary, secondary, tertiary) where outbreak took place?  |
| Unit(s) involved | Which ward/unit (s) did the outbreak take place? |
| Population | Which is the population group (adults, children, both) affected by the outbreak? |
| Age | If reported, what’s the cases’ age? |
| Agent | What’s the outbreak’s causative agent?  |
| Duration | What’s the outbreak duration (weeks)? |
| Season | Which season did the outbreak take place? |
| Risk factor(s) | Is there any reported co-morbidities that may have contributed with the infection? |
| Diagnostics | What’s the nature of the diagnostics tests described? |
| Point source(s) identification | What’s the identified point source for the outbreak? |
| IPC measures | Which are the IPC measures implemented during the outbreak? |
| ORION | Did the paper report the outbreak following the ORION guidelines, including reference to this? |

**Table 2.** List of the 125 papers reviewed

| **No.** | **First author and publication year** | **Country of publication** | **No. Cases** | **Point source** | **Effective outbreak control measures**  |
| --- | --- | --- | --- | --- | --- |
|  | Abdelfattah et al. 2018 | Saudi Arabia | 14 | Contaminated ultrasound gel | (1)hospital-wide withdrawal of the contaminated gel. |
|  | Abe et al. 2008 | USA | 10 | Unconfirmed source | - |
|  | Álvarez-Lerma et al. 2008 | Spain | 5 | Moisturizer body milk | (1)product withdrawn from ICU and then hospital; (2)cleaning measures were intensified; (3)contact precaution measures were established. |
|  | Anderson et al. 1991 | USA | 38 | Unconfirmed source | - |
|  | Antony et al. 2016 | India | 3 | Contaminated distilled water | (1)hand washing technique reminders; (2)cleaning measures were intensified; (3)ICU staff screening; (4)isolating infected patients; (5)environmental decontamination and terminal cleaning.  |
|  | Balkhy et al. 2005 | Saudi Arabia | 52 | Contaminated multidose albuterol nebulisation solution | (1)withdrawal of medication; (2)revisiting respiratory therapy practices. |
|  | Bassett et al. 1970 | UK | 9 | Contaminated piped water supply | (1)regular swabbing and clean-up implemented; (2)implementation of heat-sterilization processes for all chlorhexidine-containing disinfectants. |
|  | Baul et al. 2018 | India | 29 | Unconfirmed source | (1)evaluation of disinfection practices; (2)evaluation of prescription preparation and storage practices; (3)prohibition to prepare IV antibiotic and store them overnight in respective syringe. |

|  | Becker et al. 2018 | Germany | 5 | Contaminated Octenidine mouthwash from manufacturer | (1)creation of an infection prevention board with neighbouring regional hospitals; (2)mouthwash removal; (3)manufacturer was contacted for production process evaluation. |
| --- | --- | --- | --- | --- | --- |
|  | Berkelman et al. 1981 | USA | 52 | Contaminated Povidone-Iodine | (1)blood culture collection and processing technique improvements; (2)filtration systems installed at manufacturing plant to prevent contamination of the water to dilute the iodine powder. |
|  | Berkelman et al. 1982 | USA | 4 | Contaminated automated peritoneal dialysis machines | (1)implementation and monitoring of adequate cleaning techniques; (2)careful inspection of all machine tubes implemented; (3)entire machine disinfection if it has not been used for 24 hours implemented; (4)routine weekly disinfection with 2% formaldehyde for 12 hours implemented. |
|  | Berthelot et al. 1993 | France | 19 | Contaminated temperature sensors from ventilator | (1)regular disinfection of sinks and bronchoscopes; (2)reinforcement of hygienic measures for the nursing staff. |
|  | Boszczowski et al. 2014 | Brasil | 14 | Unconfirmed source | (1)single-patient use vials (labels with patient’s name); (2)cleaning of laminar flow cabinet and control of temperature of refrigerators were reinforced; (3)cleaning of the areas in which medication was prepared with a chlorine-based product was reinforced; (4)hand hygiene was emphasized and the number of alcohol rub dispensers in the units was increased; (5)active surveillance for new cases was implemented. |
|  | Brooks et al. 2018 | USA | 162 | Contaminated saline flushes from manufacturer | (1)evaluation of infection control procedures; (2)evaluation of product and medication exposure.  |
|  | CDC, 1998 | USA | 74 | Contaminated mouthwash | (1)revision of respiratory therapy procedures; (2)revision of ICU nursing procedures; (3)encouraging episodes reporting. |
|  | Conly et al. 1986 | Canada | 29 | Contaminated mechanical ventilator thermometer | (1)Revision of ventilator cleaning procedures; (2)Revision of procedures involving the respiratory service room; (3)Intensive education program on IC procedures implemented. |
|  | Dedeckova et al. 2012 | Czech Republic | 54 | Unconfirmed source | - |
|  | De Smet et al. 2012 | Cambodia | 8 | Contaminated in-use ringer lactate bag and dispensing pin | (1)reinforcement of aseptic procedures with sterile syringe and needle; (2)discontinuation of the use of dispensing pin; (3)monthly surveillance cultures of multidose vials. |
|  | Dolan et al. 2011 | USA | 6 | Contaminated nasal spray | (1)voluntary recalling of the product by manufacturer. |
|  | Doit et al. 2004 | France | 8 | Capped rubber stoppers of bottles of a commercial lipid emulsion for parental nutrition | (1)the batch was recalled and product online was halted in the manufacturing facility; (2)the use of lipid emulsion was stopped; (3)discontinue usage of multidose vials. |
|  | Douce et al. 2008 | Ecuador | 16 | Contaminated glass ampules of sterile water | (1)water ampules were removed. |
|  | El Shafie et al. 2003 | Qatar | 20 | Contaminated “Savlon” (chlorehexidine and cetrimide) | (1)hand washing, sterilization and disinfection policies were re-emphasized; (2)Savlon use discontinued and replaced with hot water and detergent plus disinfection with guteraldehyde for 20-30minutes; (3)rinse bronchoscopes with sterile water after disinfection; (4)separate sinks used for cleaning; (5)increasing number of bronchoscopes in use to allow adequate disinfection between patients; pharmacy to issue disinfectants in manageable quantities in sterile containers labelled with concentration and expiry date. |
|  | Estivariz et al. 2006 | USA | 20 | Contaminated multi-dose albuterol vial | (1)implementation and reinforcement of infection control measures. |
|  | Fernandez et al. 1996 | Spain | 46 | Contaminated intravenous ranitidine vial | (1)stopped dispensing intravenous ranitidine ampoules/vials. |
|  | Flaherty et al. 1993 | USA | 11 | Contaminated O-rings from dialyzers | (1)weekly water cultures measuring bacterial concentration; (2)changes on reprocessing dialyzers, so that O-rings were removed and immersed in Renalin® disinfectant as part of routine disinfection procedures. |
|  | Gautam et al. 2009 | India | 21 | Unconfirmed source | - |
|  | Ghazal et al. 2006 | Saudi Arabia | 7 | Contaminated 0.5% Salbutamol used for nebulisation  | (1)nurses instructed to avoid using povidone iodine solution when prepping skin for venous access; (2)nurses to avoid using heparin for IV flushing unless ordered by a physician; (3)no more heparin prepared daily in a single bottle for all patients; (4)drug withdrawal from the market. |
|  | Gleeson et al. 2019 | New Zealand | 9 | Contaminated 4% Chlorhexidine bodywash | (1)procedures review: peritoneal dialysis catheter insertion; (2)review of storage conditions for chlorhexidine; (3)patient’s procedures review for peritoneal dialysis; (4)ensuring patient's adequate handling of the pump bottles. |
|  | Glowicz et al. 2018 | USA | 63 | Contaminated liquid Sodium docusate  | (1)regular monitoring of medical devices and procedures; (2)products used as respiratory, oral, skin care and intranasal medications were reviewed. |
|  | Graindorge et al. 2010 | France | 7 | Contaminated tap water, ventilator, room humidifier | (1)disinfection of taps, drain-offs, ventilators and humidifiers; (2)using bottled water to prepare drugs for administration via gastric tubes and for patient hygienic care; (3)reinforced medical staff handwashing. |
|  | Gravel et al. 2002 | Canada | 14 | Contaminated Indigo-carmine dye used in enteral feeding | (1)environmental sampling on sources reported as potential reservoirs by literature; (2)patient care practices and cleaning procedures were reviewed as well as pharmacy practices; (3)removal of the implicated dye from hospital inventory; (4)compliance with established hospital guidelines. |
|  | Gravel-Tropper et al. 1996 | Canada | 13 | Contaminated blood gas analyser  | (1)removal of the blood gas analyser from NICU; (2)sterilisation with ethylene oxide and all plastic components disinfected with 2% glutaraldehyde implemented; (3)rigorous maintenance program established, including a monthly wash cycle with 2% glutaraldehyde with replacement of flush bottle and cap assembly.  |
|  | Guo et al. 2017 | China | 4 | Contaminated ICU ventilator | (1)revision of ventilators cleaning and disinfection protocols; (2)infections control measures were heightened. |
|  | Hamill et al. 1995 | USA | 42 | Contaminated nebulisers and in-use bottles of albuterol | (1)confinement of infected or colonized patients to designated areas of the intensive care units; (2)meticulous attention to hand washing, aseptic technique and medication dispensing practices. |
|  | Hanulik et al. 2013 | Czech Republic | 52 | Unconfirmed source | - |
|  | Henderson et al. 1988 | USA | 16 | Contaminated water bath used for blood gas analysing | (1)emphasis on hand washing and aseptic technique; (2)revision of the set up and care of monitoring devices; (3)environmental decontaminations implemented; (4)use of squeeze bottles was discontinued; (5)regular disinfection of the water bath. |
|  | Heo et al. 2008 | Korea | 8 | Contaminated chlorhexidine | (1)hand washing by medical staff was emphasised; (2)sterilisation and disinfection of all medical instruments were reinforced; (3)antibiotic therapy was modified according to the susceptibility testing; (4)contaminated chlorhexidine solutions were recalled; (5)pharmacy staff were asked to wear gowns, gloves and face masks while handling chlorhexidine or other disinfectants. |
|  | Holmes et al. 1999 | USA | 104 | Unconfirmed source | - |
|  | Hua and Tokeshi, 2013 | USA | 4 | Unconfirmed source | - |
|  | Huang et al. 2001 | Taiwan (Republic of China) | 40 | Unconfirmed source | - |
|  | Hutchinson et al. 1996 | UK | 4 | Contaminated home-use nebulisers | - |
|  | Hutchinson et al. 2004 | Canada | 6 | Contaminated ultrasound gel | (1)ultrasound gels where removed from all the facilities and cultures were made. |
|  | Jacobson et al. 2006 | Canada | 9 | Contaminated ultrasound gel | (1)only sterile gel should be used on and in close proximity to susceptible sites; (2)opened bottles should be labelled with the date of opening; (3)all bottles to be discarded 3 months after being opened; (4)refilling of bottles should be prohibited; (5)heating of gel is acceptable for use on neonates; (6)only the minimum quantity necessary should be stocked in a unit and in a room at a given time. |
|  | Kaitwatcharachai et al. 2000 | Thailand | 9 | Contaminated diluted Chlorhexidine-cetrimide solutions | 1. use of diluted chlorhexidine-cetrimide for disinfecting the transfer forceps was discontinued; (2)subclavian catheters were removed.
 |
|  | Kaslow et al. 1976 | USA | 51 | Contaminated Benzalkonium antiseptic | (1)monitoring of tabulated clinical and epi data; (2) cultures of antiseptic storage bottles, stock solution, distilled water used to dilute and saturated cotton swabs of the venepuncture trays were implemented; (3)alcohol and iodine were adopted for skin preparation prior to venepuncture; (4)policy compliance and enforcement in terms of the disinfectant use by staff. |
|  | Katsiari et al. 2012 | Greece | 21 | Unconfirmed source | - |
|  | Keizur et al. 1993 | USA | 11 | Contaminated ultrasound gel | (1)implementation of individual sterile packages of US transmission gel; (2)reusable squeeze bottle dispensers for invasive procedures avoided. |
|  | Ko et al. 2015 | Korea | 40 | Contaminated 0.5% chlorhexidine from sealed bottles | (1)suspension of 0.5% CHD products through all hospital; (2)re-education of the health care workers in charge of blood culture phlebotomy to use only povidone iodine as antiseptic; (3)check for breaches in IC procedures from staff; (4)proper labelling for disinfectants in terms of dilutions; (5)coordination of major changes in IC policies of all family hospitals. |
|  | Kotsanas et al. 2008 | Australia | 4 | Contaminated water tap | (1)immediate sampling of the surrounding environments to the 2 neonates cots; (2)decontamination of sinks with sodium hypochlorite implemented; (3)water tap replacement; (4)yearly microbiology sampling of all non-touch taps in the NICU only; (5)disinfection by thermal shock flushing, changing taps and disinfection of sinks with hypochlorite as required to prevent colonisation with Bcc. |
|  | Kutty et al. 2007 | USA | 116 | Contaminated alcohol-free mouthwash | (1)testing of different lots of one container. |
|  | Kuzumoto et al. 2011 | Japan | 9 | Unconfirmed source | (1)microbiological verification of hand-washing for personnel (palm stamp method); (2)reinforcement of the hygiene measuresemphasis on hand hygiene protocols and screening. If not passed, personnel had to attend the lectures on hand-washing and on hygiene. Then rechecked by Infection Control Nurse. |
|  | Lalitha et al. 2014 | India | 13 | Contaminated anaesthetic eye drop | (1)search for the agent in the operating room; (2)surveillance samples from machines, disinfectants, local anaesthetic eye drops, irrigation solutions for scrubbing, fomites; (3)new unopened bottles from pharmacy were examined; (4)discontinuation of the eye drops in that hospital. |
|  | Ledson et al. 1998 | UK | 5 | Unconfirmed source | - |
|  | Lee CS et al. 2008 | Korea | 34 | Contaminated Benzalkonium chloride solution | (1)the 4L storage containers used to keep BAC solutions started being disinfected and sterilized, not only washed; (2)the use of BAC-soaked cotton balls for cleaning skin and soft tissue or catheters was prohibited. |
|  | Lee J, 2008 | Malaysia | 23 | Unconfirmed source | (1)all new admissions were redirected to a temporary NICU in another wing of the building; (2)the use of multiple-dose drug such as heparinised saline was discontinued after the first outbreak; (3)reinforcement of IC measurements. |
|  | Lee S et al. 2013 | Korea | 20 | Contaminated purified water to dilute chlorhexidine | (1) BCC incidence monitoring before and through outbreak; (2)sampling of disinfectants, bottles, water; (3) chlorhexidine solutions prepared in hospital laboratory prohibited by the infection prevention control team; (4) staff was instructed regarding antiseptic techniques and requested to use sterile distilled water and bottles for preparation of the chlorhexidine solutions. |
|  | Liao et al. 2011 | Taiwan | 95 | Unconfirmed source | (1)discontinuing all reusable ventilator circuits, including tubing, connectors and humidifiers, which were considered the culprit of this outbreak; (2)enhancement of environmental cleaning and program launched to decrease the use of central catheters and carbapenems. |
|  | Lo Cascio et al. 2006 | Italy | 38 | Contaminated napkins from a dressing kit | (1)environmental cultures were collected on the well-known potential sources of Bcc: water, fluids from all machines, tap water, dialyser blood lines, disinfectants made up at the hospital pharmacy. |
|  | Loukil et al. 2003 | France | 32 | Unconfirmed source | (1)procedural audit for use, maintenance and disinfection of the respiratory therapy devices in the PICU; (2)only disposable, sterilizable or easy-to-disinfect materials were implemented in the PICU; (3)since ventilator use and maintenance revealed not being sterilized but simply cleaned and disinfected between patients, these was amended. |
|  | Lucero et al. 2011 | USA | 16 | Contaminated tap water from hospital sink | (1)revision of staff adherence to hand hygiene and isolation precautions; (2)environmental cleaning, respiratory equipment disinfection; (3)observation and interviewing of healthcare workers; (4)changes in protocols for tracheostomy care and assigned cleaning responsibilities; (5)no longer tap water used for oral and tracheostomy care in ventilated patients and to rinse tube feeding bags. |
|  | Magalhaes et al. 2003 | Brasil | 6 | Contaminated reverse osmosis membranes from haemodialysis system | (1)water (reservoir, tap, de-ionized and post osmosis), filters, membranes and ducts from the haemodialysis system were sampled and rigorously cleaned and/or replaced. |
|  | Mali et al. 2017 | India | 76 | Contaminated rubber stopper of amikacin injection vials | (1)environmental, clinical and pharmaceutical samples as well as disinfectants used in PICU and paediatric ward were tested to trace source; (2)the batch of multidose amikacin was discarded; (3)enforcing strict adherence to hand hygiene; (4) replacement of multidose amikacin vials with ampoules.  |
|  | Maningo and Watanakunakorn, 1995 | USA | 79 | Unconfirmed source |  |
|  | Mann et al. 2010 | Israel | 17 | Unconfirmed source | 1. work schedules of HCW were reviewed and execution of different procedures observed. Catheters were removed and cultured in all patients; (2) barrier precautions for patient management; usage of single dose bottles of medications when possible; appropriate aseptic techniques and HCW education on the topic.
 |
|  | Manzar et al. 2004 | Oman | 4 | Unconfirmed source | (1)high-dependency unit was closed to new admissions and all babies were cohorted; (2) hygiene measures including strict handwashing and barrier nursing were enforced; (3)handwashing compliance and use of gloves, gowns, etc. |
|  | Marquez et al. 2017 | USA | 24 | Contaminated liquid docusate | (1)liquid docusate removed from hospital formulary; (2)available stock quarantined; (3)notification that drug was no longer available; within hours-alert to all providers of patients with active orders for docusate; (4)import alert; (5) improvement of other infection prevention practices within the facility |
|  | Martin et al. 2011 | Germany | 61 | Contaminated prefabricated moist wash cloths  | (1)testing and disinfection of medical equipment and products used for ventilator care and mouth hygiene; (2)elimination of the prefabricated washcloths after confirming that also different ways of usage were present among staff.  |
|  | Martins et al. 2010 | Brasil | 25 | Contaminated Bromopride vial | (1)communication between hospitals’ infection control departments; (2)national recall of bromopride vials. |
|  | Martone et al. 1981 | USA | 56 | Contaminated aqueous cocaine used as topical anaesthetic and Lidocaine | (1)discarding all solutions of cocaine in dropper bottles; (2)new dropper bottles filled with fresh, sterile aqueous cocaine were discarded after 1 use; (3)use of nonsterile irrigators was discouraged; (4) solutions for intrabronchial instillation were to be drawn immediately before each procedure; (5)multidose vials of lidocaine and saline were to be discarded at the end of the day. |
|  | Matrician et al. 2000 | USA | 69 | Contaminated mouthwash | (1)staff were asked to glove for all ventilator contact; (2)vent-setting changes; (3)remove gloves and wash hands after contact; (4)handwashing campaign was instituted; (5)frequent in-service to the ICU and respiratory therapy department staff |
|  | Meyer G, 1973 | USA | 4 | Contaminated intravenous fluids and catheters | (1)close monitoring of the blood procedures; (2)a recommendation was made to use pre-packaged alcohol swabs instead of the gauze swabs usually kept in large containers. |
|  | Miyawaki et al. 1995 | Japan | 36 | Contaminated nebulization devices | (1)extensive survey of hospital environment and equipment was carried out; (2)replacement of the nebulizers sterilization method from sodium hypochloride (0.1%) to ethylene oxide gas. |
|  | Moehring et al. 2014 | USA | 7 | Contaminated intravenous Fentanyl  | (1)environmental exploration was performed and source was identified; (2) remaining fentanyl syringes were immediately removed from circulation; (3)hospital secured an alternate manufactured supply. |
|  | Molina-Cabrillana et al. 2006 | Spain | 37 | Contaminated Alcohol-Free Mouthwash | (1)batches of bottles of mouthwash were removed from the ward and were investigated; (2)batches of bottles of contaminated mouthwash were discontinued; (3)production and distribution methods of this mouthwash in other hospitals were investigated. |
|  | Moreira et al. 2005 | Brasil | 5 | Contaminated water vials used for injection | (1)all water vials in stock were discarded in the facility; (2)water vials were replaced with products obtained from different manufacturers. |
|  | Nannini et al. 2015 | Argentina | 11 | Contaminated ultrasound gel | (1)environmental samples taken for culture, including several solutions of antiseptics and multiple surfaces in the surgical room, ICU and NU; (2)contaminated ultrasound gel stocks were removed. |
|  | Nasser et al. 2004 | Lebanon | 50 | Contaminated tap water routinely used for alcohol dilution | (1)health staff instructed to use sterile water for alcohol dilution; (2)individually packaged, single-use alcohol swabs and povidone-iodine were issued and distributed for intravenous catheter insertion hospital wide and afterwards; (3)personnel were instructed to use sterile water for alcohol dilution. |
|  | Okazaki et al. 1999 | Japan | 13 | Contaminated nebulizing solution  | (1)careful observation of the routine precautionary measures against the spread of infections. |
|  | Organ et al. 2010 | Canada | 6 | Contaminated ultrasound gel | (1)antibiotic treatment, urinary and blood cultures to clarify what was affecting the patients; (2)consultations with infection diseases specialists; (3)single sterile packets of US gel were recommended to be used for each patient; (4)refilling of squeeze bottles with US gel was banned. |
|  | Otag et al. 2005 | Turkey | 7 | Contaminated distilled water used in a ventilator humidifier | - |
|  | Ouchi et al. 1995 | Japan | 4 | Unconfirmed source | - |
|  | Panlilio et al. 1992 | USA | 6 | Contaminated Povidone-Iodine Solution | (1)skin disinfection process was reviewed; (2)risk factors were explored and identified; (3)on-site investigations of the manufacturing plant were conducted by the FDA and the CDC; (4)changes made in the water-treatment/process line-distribution system; (5)production site moved to a new plant in another state. |
|  | Patra et al. 2014 | India | 12 | Unconfirmed source | - |
|  | Paul et al. 2016 | India | 12 | Contaminated opened multi-use IV fluid bottles (5% Dextrose, 0.9% saline) and ventilator humidifier water | (1)single use of IV fluids; (2)care of IV lines; (3) cleaning of ventilator circuits. |
|  | Pegues CF et al. 1996 | USA | 70 | Unconfirmed source | (1)review of procedures for administration of nebulised medication for non-ventilated patients by either respiratory therapists or trained nurses; (2)use of standard procedures and disinfection practices for nebulised medications; (3)nebuliser disinfection or rinsing with sterile water and air dried between each use implemented; (4)compliance with strict handwashing and glove changing (when used) between patient contacts. |
|  | Pegues DA et al. 1993 | USA | 18 | Contaminated multi-use bag of IV 5% dextrose used to prepare heparin flush solution | (1)stopped using the contaminated bag of IV 5% dextrose (had been in use from 7 -21 August); (2)CVC catheters accessed aseptically and flushed with solutions that did not contain glucose; (3)use single-use (single-dose) containers for the preparation of IV flush solutions; (4) ongoing surveillance for *P. cepacia* bacteraemia. |
|  | Perera and Palasuntheram, 2000 | Sri Lanka | 17 | Unconfirmed source | - |
|  | Peterson et al. 2013 | USA | 10 | Contaminated tap water | (1)immediate changes to respiratory therapy procedures e.g. not rinsing nebulizer cups with tap water and storing them wet; (2)hand hygiene protocols reviewed; (3)aerators removed from surgical ICU manual and automatic sinks; (4)in-room carts provided to eliminate the need to store patient care products beside the sink in splashing proximity. |
|  | Ramsey et al. 2001 | USA | 9 | Association with treatment by one respiratory therapist (RT) | (1)strict aseptic techniques when using multidose albuterol vials between patients; (2)discarding unused portions of the product every 24 hours (hospital policy not followed); (3) inner portions of small-volume nebulisers were to be dried after every use (not in hospital policy-that referenced only outside of the nebulisers); (4) new RTs to shadow experienced RTs for 3 or 4 weeks before working alone. |
|  | Rapkin R, 1976 | USA | 8 | Unconfirmed source | (1) review of all patients admitted to the intensive care nursery, with specific attention to exposure to humidifiers and respirators; (2)proper disinfection of equipment, particularly laryngoscopes and oxygen humidifier bottles; (3)sterile distilled water was made compulsory; (4)strong encouragement for physicians, inhalation therapists, pharmacists and supply people to recognize the misuse of unsterile distilled water. |
|  | Rastogi et al. 2019 | India | 48 | Contaminated water supply | (1) isolation and cohort of infected patients; (2)disinfection of each cubicle with hydrogen peroxide, heat disinfection of fabric material, hand hygiene reinforcement, PPE; (3)water tanks cleaning and disinfection. |
|  | Reboli et al. 1996 | USA | 57 | Unconfirmed source | (1)observation of the nebulisation techniques of the respiratory therapists, including handwashing and care of the nebuliser cups; (2)infection control personnel educated respiratory therapists on proper nebulisation techniques, washing and drying the nebuliser cup; (3)handwashing. |
|  | Righi et al. 2013 | Italy | 46 | Contaminated mouthwash | (1)product removal. |
|  | Romero-Gomez et al. 2008 | Spain | 5 | Contaminated 2.5% Chlorhexidine solution | (1)contaminated 2.5% chlorhexidine solution diluted with tap water by health care workers from a specific water tap were discarded; (2)water tap was cleaned with solutions of sodium hypochlorite and 80% v/v ethanol; (3)the use of diluted alcohol-free chlorhexidine solution was discontinued and followed the manufacturer's instructions of adding alcohol to dilute the chlorhexidine for skin disinfection before catheter insertion and during follow up care. |
|  | Rosengarten et al. 2010 | Israel | 4 | Contaminated automated endoscope used for cleaning and disinfecting bronchoscopes  | (1)routine bronchoscopies suspended and manual disinfection of bronchoscopes implemented; (2)reprocessing procedure and equipment reviewed; (3)manual cleaning and disinfection of the automated endoscope washer-disinfector and installed a missing 0.2 -um bacteria-retentive filter on the water supply line; (4)adherence to installation instructions for washer-disinfectors and to infection control practice procedures. |
|  | Serikawa et al. 2010 | Japan | 17 | Contaminated Benzalkonium Chloride and irrigators  | (1)hospital stopped using irrigators immediately and started using commercial 0.035% Benzalkonium Chloride; (2) saline was used for internal examination of irrigators. |
|  | Shaban et al. 2017 | Australia | 11 | Contaminated ultrasound gel | (1)the gel kits were removed from the associated hospitals; (2)Australian Therapeutic Goods Administration was notified; (3)distributor and manufacturer were notified, issued a notice of recall, and classified the event as life-threatening. |
|  | Shehabi et al. 2004 | Jordan | 26 | Unconfirmed source | (1)strict hospital infection control measures were instituted immediately after the appearance of the sixth case. |
|  | Shrivastava et al. 2016 | India | 7 | Contaminated Caffeine Citrate | (1)all vials of caffeine citrate were recalled from pharmacy stores; (2)the drug brand was immediately withdrawn from the hospital and replaced with another brand; (3)report of the incident was made to the FDA. |
|  | Siboni et al. 1979 | Denmark | 16 | Contaminated fentanyl vials | (1)due to previous experience with an outbreak involving anaesthetics multidose vials, all vials in use and empty were evaluated.  |
|  | Siddiqui et al. 2001 | USA | 31 | Unconfirmed source | (1)contact isolation was initiated;(b) All healthcare personnel and visitors to use disposable gloves for entry into patient rooms and to wear gloves and gowns for direct patient contact; (c) Infection control personnel conducted educational programs for nurses and respiratory therapists to review infection control measures; (2) |
|  | Singhal et al. 2015 | India | 13 | Contaminated antiemetic drug | (1) Contaminated antiemetic brand was withdrawn; (2)use of only collapsible/closed intravenous fluid bags was initiated; (3)the process of insertion of ports was reviewed; (4)microbiologic cultures were taken from environmental surfaces; (5)the entire day care unit was fogged and disinfected; (6)compliance to all infection control protocols was assessed, corrected if required and made more stringent; (7)hand hygiene was reinforced; (8)medication preparation and administration was regulated. |
|  | Smith et al. 1993 | UK | 17 | Person-to-person transmission outside the healthcare facility | - |
|  | Sobel et al. 1982 | Israel | 47 | Contaminated chlorhexidine gluconate | (1)chlorhexidine supply was evaluated for contamination; (2) the use of chlorhexidine was restricted to perineum and genitalia cleansing prior to catheterization; (3) pharmacy replaced concentrated chlorhexidine dilution with nonsterile deionized water to sterile water only. |
|  | Soltand-Dallal, M. 2014 | Iran | 5 | Unconfirmed source | - |
|  | Sommerstein et al. 2017 | Switzerland | 46 | Contaminate washing gloves | (1)Swissmedic published a product recall alert and the Swiss distributor sent a letter to customers informing them that all products should be returned to them pending further investigation. |
|  | Song et al. 2018 | Korea | 21 | Contaminated chlorhexidine gluconate solution | (1)infection Control Team checked and reminded medical staff in the NICU of the basic principles of infection control, including hand hygiene and disinfection of medical devices; (2)CHG solution's use in the hospital was suspended; (3)All NICU staff re-educated to use 10% povidone-iodine alone for skin antisepsis; (4)CHG solution was recalled by the ministry of Food and Drug Safety. |
|  | Souza Diaz et al. 2013 | Brazil | 7 | Contaminated mannitol 3% solution  | (1)mannitol solution use was suspended and replaced by a non-manipulated equivalent (glycin 1.5% solution); (2) notification of the outbreak informally to 7 other hospitals which share similar purchasing mechanisms and providers. |
|  | Souza et al. 2004 | Brazil | 35 | Contaminated water system within haemodialysis unit | (1) the haemodialysis procedure, including equipment disinfection and the whole water system were reviewed; (2) check-up and repair of a loose connection in the reverse osmosis tube that had led to a lea allowing entrance of bacteria into the water system.  |
|  | Steere et al. 1977 | USA | 11 | Contaminated human serum albumin | (1) the physicians removed the albumin infusion apparatus; (2)a prevalence survey of normal serum albumin at central supply level was carried out; (3) manufacturer recalled all of its normal serum albumin. |
|  | Sunenshine et al. 2009 | USA | 6 | Contaminated trypan blue  | (1) customers notification and pharmacy's voluntary recall of all unexpired trypan blue syringes; (2) company voluntarily ceased compounding all sterile solutions. They no longer offer trypan blue and do not ship it out of state. |
|  | Takigawa et al. 1993 | Japan | 36 | Contaminated nebulization devices | (1)extensive survey about hospital environment and equipment including water pipes, respirator machine, oxygen inhaler, humidifier and nebulizer devices; (2)analysis routine cleaning protocols; (3)changes to disinfection method including disassembling, daily disinfection with sodium hypochlorite and weekly autoclaving; (4)changes in the use of nebulizer devices from sharing to individual, to prevent cross-infection. |
|  | van Laer et al. 1998 | USA | 8 | Contaminated dextrose solution and heparin | 1. inspection of the cardiology ward and the catheterization laboratory; (2)samples of disinfectants, solutions, perfusion bags, sand bags, pressure transducers, sink, refrigerator; (2)revision of all procedures on the ward; (3)use of sterile water for the preparation of medication; (4)education of all cardiology-ward staff of the consequences of using procedures as the ones taking place around the outbreak.
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|  | Vardi et al. 2013 | Greece | 10 | Unconfirmed source | (1)strict IC measures were instituted; (2)every patient was isolated in his/her own room; (3)hand washing on entry and exit; (4)gowns, gloves and masks enforced; (5)visiting restrictions; (6)assessment of IC practices for staff and cleaners; (7)special focus on compliance to aseptic techniques during preparation and administration of IV medications; (8)room cleaning procedures compliance; (9)educational meetings; (10)multidose vials discarded; (11)negative results of environmental cultures were necessary for reopening the room and admitting new patient; (12)compliance of IC preventive practices; (13)assessments and educational sessions.  |
|  | Wang et al. 2015 | China | 53 | Unconfirmed source | (1) environmental screening and infection control measures including surfaces, taps and medical devices disinfected with 75% alcohol; (2)revision of the nasal endoscope disinfection time plus use of a high-level disinfectant; (3)hand hygiene was strengthened in the ward; (4)nasal endoscope disinfection time was increased to 10 minutes as well as better environmental disinfection; (5)encouraging staff to pay attention to asymptomatic colonization to avoid outbreaks.  |
|  | Weems J, 1993 | USA | 127 | Contaminated electronic temperature probes from mechanical ventilators plus bucket used for disinfection | (1)all temperature probes currently in use were removed; (2)disinfection procedure for temperature probes was developed; (3)following year, the manufacturer released a redesigned temperature probe the tip could undergo high-level disinfection).  |
|  | Whiteford et al. 1995 | UK | 23 | Unconfirmed source | (1)segregation measures were implemented. Colonized children were moved to a different waiting area and given appointment times at the end of the clinic ; (2)letters encouraging avoidance of close physical contact with other CF children outside hospital were sent; (3)No longer use of communal physiotherapy in an enclosed space, which may have inadvertently created spread.  |
|  | Wiener-Well et al. 2014 | Israel | 4 | Contaminated moisturizing cream | (1)moisturizing cream was withdrawn from all hospital departments; (2)recommendations were made suggesting avoidance of nonsterile cosmetic products in special populations such as ICU and immunocompromised-patients while hospitalized. |
|  | Woods et al. 2004 | USA | 53 | Unconfirmed source | - |
|  | Yamagishi et al. 1993 | Japan | 37 | Contaminated nebulization devices | - |
|  | Yamunadevi et al. 2018 | India | 24 | Contaminated ultrasound gel | (1)change on the disinfectant that was used to wipe the gel from patient's body; (2)sterile covers were used for US probes avoiding contact with skin; (3) the outbreak-related measures were kept and also US probes were cleaned with alcohol spray between each patient use; (4)sterile gel was introduced. |
|  | Yan et al. 2008 | China | 10 | Contaminated reverse osmosis water system for renal dialysis | (1)rigorous cleaning of the water reservoir and ducts; (2)filter and membranes replacement of the haemodialysis system; (3) monitoring the bacterial count in the water supply for the haemodialysis setting is now mandatory. |
|  | Yang et al. 2008 | Taiwan | 15 | Contaminated daily prepared diluted heparin solution | (1)infection control monitoring and staff education when they first notice outbreak; (2)venous catheter flushing practice was stopped and the contaminated heparin solution was discarded; (3)no more multiple-use heparin vials; (4) education and highlighting the risk on using multiple-use heparin solutions. |
|  | Zou et al. 2019 | China | 9 | Contaminated analgesic gel  | (1)regular collection of isolates from hands of surgeons and nurses, products used, surgical instruments; (2)thorough cleaning and disinfection of surgical equipment; (3)training for nurses and surgeons to improve aseptic techniques. |
|  | Zurita et al. 2014 | Ecuador | 13 | Contaminated alcohol-free mouthwash | (1)the use of mouthwash in the hospital was discontinued; (2)once intrinsic contamination of the mouthwash was confirmed, the methods to aliquot and distribute the product and the extent of use in other hospitals were investigated. |

**Table 3**. Clinical risk characteristics of cases with B. cepacia HAI

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| --- | --- | --- |
| **Clinical risk characteristics** | **Frequency (n) and percentage (%)** | **Total frequency (n) and percentage (%)** |
|  | Yes | No |  |
| Indwelling device (vascular or urinary) present  | 74 (59.2) | 51 (40.8) | 125 (100) |
| Other respiratory illness (non-cystic fibrosis) | 45 (36.3) | 79 (63.7) | 125 (100) |
| Haematology/oncology-related | 39 (31.2) | 86 (68.8) | 125 (100) |
| Cardiovascular condition | 38 (30.6) | 86 (69.4) | 125 (100) |
| Immunosuppression | 27 (21.6) | 98 (78.4) | 125 (100) |
| Diabetes-related | 19 (15.2) | 106 (84.8) | 125 (100) |
| Cystic fibrosis-related | 11 (8.8) | 114 (91.2) | 125 (100) |
| Premature birth | 11 (8.8) | 114 (91.2) | 125 (100) |
| COPD-related | 8 (6.5) | 116 (93.5) | 125 (100) |
| Asthma-related | 0 (0) | 124 (100) | 125 (100) |