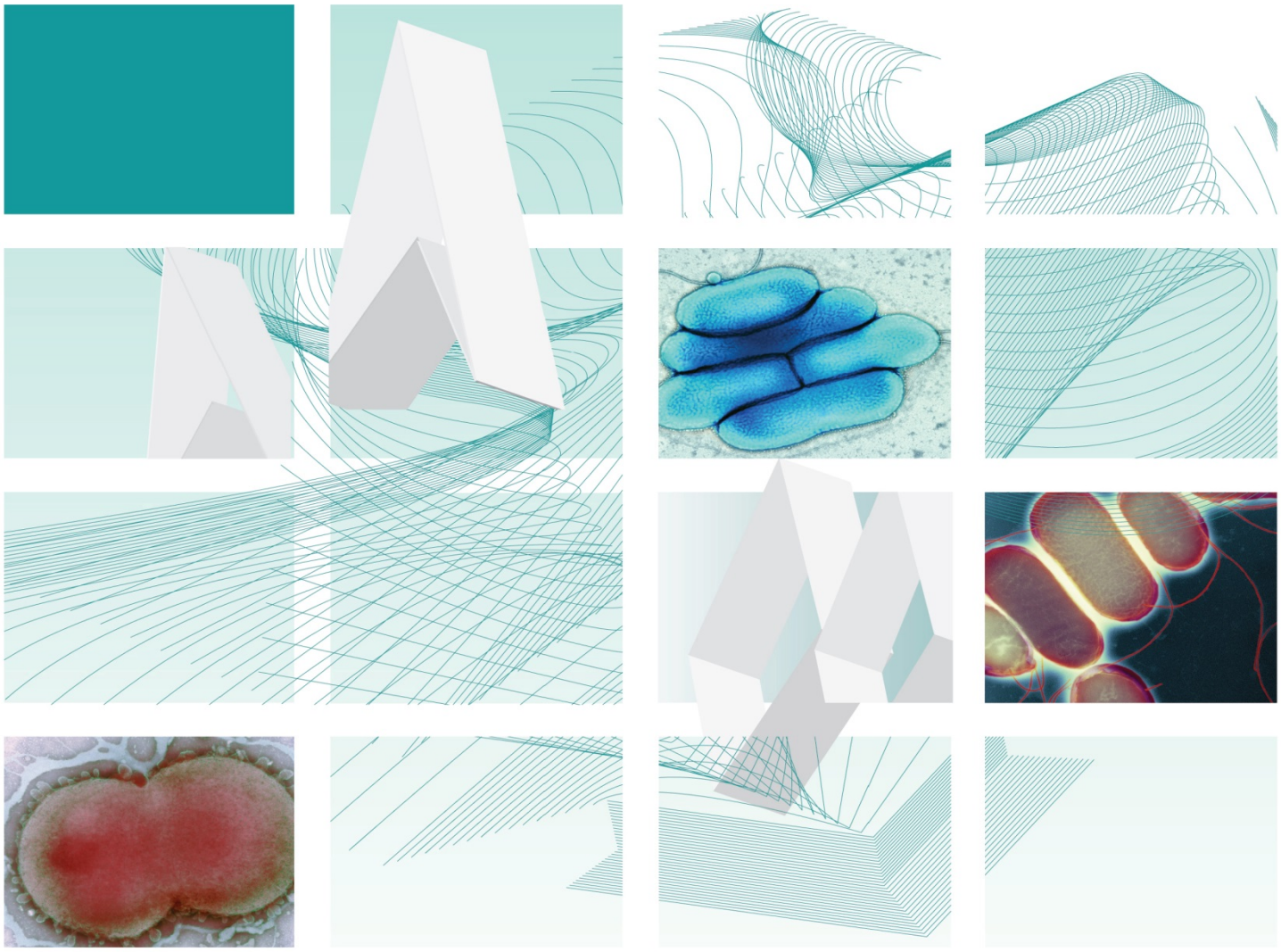
Public Health England

NHS

UK Standards for Microbiology Investigations

Investigation of swabs from skin and superficial soft tissue infections



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For further information please contact us at:

Standards Unit
Microbiology Services
Public Health England
61 Colindale Avenue
London NW9 5EQ

E-mail: standards@phe.gov.uk

Website: https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories

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Amendment table

Each SMI method has an individual record of amendments. The current amendments are listed on this page. The amendment history is available from standards@phe.gov.uk.

New or revised documents should be controlled within the laboratory in accordance with the local quality management system.

Amendment no/date.	9/04.05.16
Issue no. discarded.	5.2
Insert issue no.	6
Section(s) involved	**Amendment**
Whole document.	Title updated to indicate sample type. References reviewed and updated throughout. Hyperlinks updated to gov.uk.
Scope.	Inclusion of swabs of pus. Inclusion of links to relevant SMIs.
Page 2.	Updated logos added.
Key recommendations.	Key recommendations included.
Introduction.	Original text reorganised and streamlined. Additional text included from B14 – Investigation of pus and exudates and B17 – Investigation of tissues and biopsies from deep-seated sites and organs following reorganisation of these documents.
Technical information/limitations.	Section of rapid methods included.
Specimen processing/procedure.	4.5.1 Culture media and organisms Specimen type added to table. All conditions – addition of Staph/Strep selective agar as an alternative to blood agar. Addition of CLED/MacConkey agar. Addition of swab of pus to supplementary media section. Removal of reference to swabs from dirty sites. Sabouraud agar incubation amended to 28-30ºC for 14d.

	4.6.1 Minimum level of identification Aeromonas, dermatophytes and mould added to the table. Additional information included in right hand column regarding exceptions and information for specific situations. Information regarding *C. diphtheria* included. 4.7 Antimicrobial susceptibility testing Updated to include link to EUCAST and reference to CSLI. Antimicrobial susceptibility testing table included which recommends which antimicrobials should be tested and reported.
Reporting procedure.	Reporting procedure text updated in line with template.

UK SMI[#]: scope and purpose

Users of SMIs

Primarily, SMIs are intended as a general resource for practising professionals operating in the field of laboratory medicine and infection specialties in the UK. SMIs also provide clinicians with information about the available test repertoire and the standard of laboratory services they should expect for the investigation of infection in their patients, as well as providing information that aids the electronic ordering of appropriate tests. The documents also provide commissioners of healthcare services with the appropriateness and standard of microbiology investigations they should be seeking as part of the clinical and public health care package for their population.

Background to SMIs

SMIs comprise a collection of recommended algorithms and procedures covering all stages of the investigative process in microbiology from the pre-analytical (clinical syndrome) stage to the analytical (laboratory testing) and post analytical (result interpretation and reporting) stages. Syndromic algorithms are supported by more detailed documents containing advice on the investigation of specific diseases and infections. Guidance notes cover the clinical background, differential diagnosis, and appropriate investigation of particular clinical conditions. Quality guidance notes describe laboratory processes which underpin quality, for example assay validation.

Standardisation of the diagnostic process through the application of SMIs helps to assure the equivalence of investigation strategies in different laboratories across the UK and is essential for public health surveillance, research and development activities.

Equal partnership working

SMIs are developed in equal partnership with PHE, NHS, Royal College of Pathologists and professional societies. The list of participating societies may be found at https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories. Inclusion of a logo in an SMI indicates participation of the society in equal partnership and support for the objectives and process of preparing SMIs. Nominees of professional societies are members of the Steering Committee and Working Groups which develop SMIs. The views of nominees cannot be rigorously representative of the members of their nominating organisations nor the corporate views of their organisations. Nominees act as a conduit for two way reporting and dialogue. Representative views are sought through the consultation process. SMIs are developed, reviewed and updated through a wide consultation process.

Quality assurance

NICE has accredited the process used by the SMI Working Groups to produce SMIs. The accreditation is applicable to all guidance produced since October 2009. The process for the development of SMIs is certified to ISO 9001:2008. SMIs represent a good standard of practice to which all clinical and public health microbiology

[#] Microbiology is used as a generic term to include the two GMC-recognised specialties of Medical Microbiology (which includes Bacteriology, Mycology and Parasitology) and Medical Virology.

laboratories in the UK are expected to work. SMIs are NICE accredited and represent neither minimum standards of practice nor the highest level of complex laboratory investigation possible. In using SMIs, laboratories should take account of local requirements and undertake additional investigations where appropriate. SMIs help laboratories to meet accreditation requirements by promoting high quality practices which are auditable. SMIs also provide a reference point for method development. The performance of SMIs depends on competent staff and appropriate quality reagents and equipment. Laboratories should ensure that all commercial and in-house tests have been validated and shown to be fit for purpose. Laboratories should participate in external quality assessment schemes and undertake relevant internal quality control procedures.

Patient and public involvement

The SMI Working Groups are committed to patient and public involvement in the development of SMIs. By involving the public, health professionals, scientists and voluntary organisations the resulting SMI will be robust and meet the needs of the user. An opportunity is given to members of the public to contribute to consultations through our open access website.

Information governance and equality

PHE is a Caldicott compliant organisation. It seeks to take every possible precaution to prevent unauthorised disclosure of patient details and to ensure that patient-related records are kept under secure conditions. The development of SMIs are subject to PHE Equality objectives https://www.gov.uk/government/organisations/public-health-england/about/equality-and-diversity.

The SMI Working Groups are committed to achieving the equality objectives by effective consultation with members of the public, partners, stakeholders and specialist interest groups.

Legal statement

While every care has been taken in the preparation of SMIs, PHE and the partner organisations, shall, to the greatest extent possible under any applicable law, exclude liability for all losses, costs, claims, damages or expenses arising out of or connected with the use of an SMI or any information contained therein. If alterations are made by an end user to an SMI for local use, it must be made clear where in the document the alterations have been made and by whom such alterations have been made and also acknowledged that PHE and the partner organisations shall bear no liability for such alterations. For the further avoidance of doubt, as SMIs have been developed for application within the UK, any application outside the UK shall be at the user's risk.

The evidence base and microbial taxonomy for the SMI is as complete as possible at the date of issue. Any omissions and new material will be considered at the next review. These standards can only be superseded by revisions of the standard, legislative action, or by NICE accredited guidance.

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https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories

Scope of document

Type of specimen

Skin swab, swab from superficial, non-surgical and surgical wounds, and swab of pus

This SMI describes the processing of skin, superficial, non-surgical and surgical wound swabs, from sites accessible without intervention, for the microbiological investigation of skin and superficial soft tissue infections (SSTIs).

For pragmatic reasons the processing of swabs of pus has been included in this SMI. For further information regarding pus and exudate samples refer to B 14 – Investigation of pus and exudates.

It should be noted that many conditions are best diagnosed by submission of a skin biopsy for culture and histopathological examination (refer to B 17 - Investigation of tissues and biopsies from deep-seated sites and organs).

For information regarding dermatophyte infections see B 39 - Investigation of dermatological specimens for superficial mycoses.

Investigation of genital ulcers is dealt with in B 28 - Investigation of genital tract and associated specimens. Viruses such as herpes simplex and varicella-zoster, as well as parasites and non-microbial agents, may also cause skin lesions but are outside the scope of this SMI.

This SMI should be used in conjunction with other SMIs.

Key recommendations

Swabs are a diverse and heterogeneous group of specimens.

The specimen type and clinical details must therefore be taken into consideration when processing samples[1]. For example, swabs of pus should be investigated in a similar way to pus samples. In addition to the standard media recommended, supplementary media (ie fastidious anaerobic, cooked meat broth or equivalent) is also required for these samples. Refer to table 4.5.1.

A mechanism for urgent reporting should be in place to communicate key, clinically significant results in a timely manner.

Introduction

The skin is colonised by normally non-harmful flora. When the skin is broken as a result of trauma, burns, bites or surgical procedures, colonisation with a range of bacteria may occur[2]. Infections of the skin and subcutaneous tissues are caused by a wide range of organisms, however the majority are caused by *Staphylococcus aureus* and β haemolytic streptococci groups A, C and G[3,4].

Particular organisms are often typically associated with specific clinical conditions in skin and soft tissue infections, however overlaps in clinical presentation do occur[3,4]. Diagnosis is normally based on clinical presentation. Guidelines for diagnosis and management have been published which focus on a wide range of SSTIs from minor superficial to life threatening infections[5]. Microbiological cultures may be undertaken to

establish the causative organism enabling antibiotic sensitivity testing which is essential to ensure optimal treatment regimens.

Skin infections[2,4,6]

Cellulitis and erysipelas[7,8]

Cellulitis and erysipelas are diffuse spreading infections of the skin and subcutaneous tissue excluding cutaneous abscesses and necrotizing fasciitis[4]. Cellulitis involves the deeper layers of the skin and subcutaneous tissues, whereas erysipelas involves the upper dermis and superficial lymphatic system[4].

Cellulitis is commonly caused by[9,10]:

- β-haemolytic streptococci (including *Streptococcus pyogenes*)
- *S. aureus*

Wound infections may be caused by a broader range of organisms which, in addition to above, may include:

- *Bacteroides* species
- anaerobic cocci
- *Bacillus cereus*[11] (especially after trauma or orthopaedic surgery)
- enterobacteriaceae[12]

Superficial swabs in the absence of a skin break are often unrewarding; skin biopsies may produce better results but they are not frequently done. Recurrent cellulitis can occur following damage to local venous or lymphatic drainage systems[13,14].

Ecthyma gangrenosum

Ecthyma gangrenosum is a focal skin lesion characterised by haemorrhage, necrosis and surrounding erythema. It is usually caused by:

- *Pseudomonas aeruginosa*
- haematogenous dissemination of fungal infection (eg *Candida* species and mucoraceous fungi)[15,16]

Ecthyma gangrenosum may also rarely be caused by *Stenotrophomonas maltophilia*.

Similar lesions found in patients who are neutropenic may be due to infection with *Aspergillus* species or *Fusarium* species[17]. Diagnosis is usually based on clinical history and physical examination[9].

Impetigo

Impetigo is a superficial, intra-epidermal infection producing erythematous lesions that may be bullous or nonbullous[6]. Bullous impetigo is caused by *S. aureus*[4,18]. Nonbullous impetigo is most frequently caused by Lancefield Group A streptococci or *S. aureus*, and has occasionally been caused by streptococci of Lancefield Groups C and G[19].

Erysipelas

Erysipelas is a rare superficial infection of the skin[20]. It primarily involves the dermis and the most superficial parts of the subcutaneous tissues, with prominent

involvement of the superficial lymphatics. It presents as a painful, fiery red, oedematous area of skin, occasionally with small vesicles on the surface[4]. The margins have sharply demarcated, raised borders and the skin surface can appear orange peel like.

Erythrasma

Erythrasma is a common, chronic, superficial skin infection of the stratum corneum caused by *Corynebacterium minutissimum*. It presents with fine, scaly, reddish-brown plaques usually in the axillae and is often misdiagnosed as mycotic infection[21]. Diagnosis is most often made on clinical grounds rather than by culture.

Superficial mycoses

Superficial mycoses are cutaneous fungal infections that involve the hair or nails or the keratinized layer of the stratum corneum. A number of fungi can cause infection and are diagnosed through biopsy or aspirate. Normally skin scrapings are the specimens of choice (see B 39 - Investigation of dermatological specimens for superficial mycoses).

Causative organisms include[22]:

- dermatophytes
- *Candida* species
- Lipophilic yeasts

Paronychia

Paronychia is a superficial infection of the nail fold occurring as either an acute or chronic condition. Common isolates include[23]:

- *S. aureus*
- Lancefield Group A streptococci
- yeasts
- anaerobic bacteria
- *Haemophilus influenzae*

Folliculitis

Folliculitis is infection and inflammation of a hair follicle[24]. Dome-shaped papules or pustules form. These are each pierced by a hair and surrounded by a rim of erythema. The condition is usually caused by *S. aureus.*

Other possible causes include:

- *Pseudomonas aeruginosa*
  (can follow exposure in swimming pools or whirlpools)[25-28]
- *Candida* species
  (in patients receiving prolonged antibiotic or corticosteroid treatment)
- *Malassezia furfur*
  (in patients with diabetes or granulocytopenia or receiving corticosteroid treatment)[29,30]

Necrotising skin and soft tissue infections[4,10,31]

The terminology used for necrotising soft tissue infections is not consistent. Terms may relate to the kind of pathogen, the tissues involved, or the presence or absence of gas in the tissues[32,33].

It is clinically important to recognise these conditions as urgent surgical intervention, as well as antimicrobial therapy, is essential. Appropriate specimens are blood, fluid from bullae, and tissue biopsies. Growth from swabs taken from the surface of a lesion tends to be misleading, often yielding mixed cultures of colonising organisms. Mortality rates are high (30-60%)[33].

Gangrene

There are 4 main types of gangrene:

Meleney's progressive synergistic gangrene presents as a burrowing lesion or chronic gangrene of the skin usually following abdominal operations and results from mixed infections by organisms such as:

- *S. aureus*
- streptococci
- enterobacteriaceae
- pseudomonads
- anaerobic Gram negative bacilli[34]

Gas gangrene is a necrotising process associated with systemic signs of toxaemia and gas is present in the tissues. It often follows traumatic injuries such as penetrating wounds or crush injuries. Gas gangrene is caused by:

- *Clostridium perfringens*
- other *Clostridium* species

These organisms may however colonise a wound without causing disease. Alternatively, they may cause a spreading cellulitis, or extend into the muscle causing myonecrosis[10]. Classical gas gangrene is associated with clinical shock, leakage of serosanguinous fluid, tissue necrosis and presence of gas in the tissues.

Fournier’s gangrene applies to the non-sporing anaerobes. These are particularly important causes of infection in the pelvic and scrotal areas, and are common causes of gangrene in ischaemic and diabetic limbs. They often occur in infections mixed with:

- enterobacteriaceae
- streptococci
- *Clostridium* species[35]

Spontaneous gangrene occurs either with no apparent relation to trauma or following mild, non-penetrating trauma. It is most commonly seen in patients with colonic carcinoma, leukaemia or neutropaenia. The main causative organisms are[36]:

- *C. perfringens*
- *Clostridium septicum*

Actinomycosis

Actinomycosis is a chronic suppurative infection characterised by abscess formation with the production of sulphur granules which mainly consist of micro-colonies of *Actinomyces* species[36]. Usual sites of infection are around the jaw, chest or abdomen. Material should be drained from these abscesses (B 14 - Investigation of deep-seated and organ, infections and abscesses) and biopsies taken (B 17 - Investigation of tissues and biopsies from deep-seated sites and organs).

Necrotising fasciitis[37,38]

Necrotising fasciitis is a serious, infrequently occurring infection primarily affecting the subcutaneous fat and superficial fascia of muscles and often the overlying soft tissues. The infection is most commonly caused by Group A streptococci. Swabs are not the sample of choice for the investigation of this infection (refer to B 17 - Investigation of tissues and biopsies from deep-seated sites and organs).

Myositis[39]

Myositis is not strictly within the scope of this document. It is an inflammation of the muscle which may be caused by bacterial, fungal or parasitic infection as well as non-infective conditions such as autoimmune disease or genetic disorders. Localised infection is usually due to bacteria or fungi, whereas viral and parasitic infections tend to be more diffuse. Necrotising myositis rapidly involves the entire muscle bed and may spread to adjacent tissues. Both polymicrobial and unimicrobial forms may be seen.

Pyomyositis is a purulent infection of skeletal muscle and occurs more commonly in tropical countries. It usually presents as a single abscess but multiple abscesses do occur. Most patients have no underlying predisposing condition, previous trauma accounting for only 25% of cases. The majority of cases are due to *S. aureus*. More rarely, fungi and viruses may cause infection in patients who are immunocompromised.

Mycetoma[40-43]

Mycetoma occurs in people living in tropical and sub-tropical climates, usually following a puncture wound. The condition results from a chronic destructive process involving the skin, subcutaneous tissue, muscle and bone. Granulation of tissue develops with chronic inflammation and fibrosis and is characterised by a draining sinus and the presence of granules. A mycetoma can form anywhere in the body, but is more common in the lower extremities. Formation in the foot is known as Madura foot.

Mycetomata are divided into two categories based on the aetiological agents involved; actinomycetoma caused by aerobic actinomycetes and eumycetoma caused by moulds. There are at least twenty moulds that may cause this condition; the species involved are often associated with distinct geographical areas.

Ninety five percent of the cases are caused by:

Eumycetoma:

- *Acremonium* species
- *Leptosphaeria senegalensis*
- *Madurella grisea*

- *M. mycetomatis*
- *Scedosporium* (*Pseudallescheria*) *apiospermum*
- *Pyrenochaeta romeroi*
- *Curvularia* species
- *Exophiala jeanselmei*
- *Phialophora verrucosa*

Actinomycetoma:

- *Actinomadura* species
- *Nocardia* species
- *Streptomyces* species
- *Maduralla* species

Organisms are found in tissue sinuses as aggregates of filaments. These are called granules but differ from the sulphur granules of actinomycosis in that they do not have the characteristic clubbed peripheral fringe. Granules obtained directly from tissue will ensure the best cultural recovery of the causative organism because granules found in sinus discharge contain only dead organisms. Surgical biopsy to obtain material for culture is important for diagnosis, especially if sinus discharge is culture-negative for aerobic actinomycetes or is contaminated by other bacteria: the processing of tissue specimens in possible cases of mycetoma is described in B 17 - Investigation of tissues and biopsies from deep-seated sites and organs.

Carbuncles, foruncles, cutaneous, soft tissue and other abscesses[4]

Carbuncles are deep and extensive subcutaneous abscesses involving several hair follicles and sebaceous glands.

Foruncles are abscesses which begin in hair follicles as firm, tender, red nodules that become painful and fluctuant. Both carbuncles and foruncles are usually caused by *S. aureus*.

Cutaneous abscesses are usually painful, tender, fluctuant erythematous nodules often with a pustule on top. In some cases they are associated with extensive cellulitis, lymphangitis, lymphadenitis and fever. They are caused by a variety of organisms. The location of an abscess often determines the flora likely to be isolated. Thus *S. aureus* is most often isolated from cutaneous abscesses of the axillae, the extremities and the trunk, whereas cutaneous abscesses involving the vulva and buttocks may yield faecal or urogenital mucosal flora.

Burkholderia pseudomallei causes melioidosis, but is rare in the UK. The disease may present in a variety of forms with skin lesions and/or cellulitis. Diagnosis is made by blood culture, serology or culture of pus (refer to B 37 – Investigation of blood culture (for organisms other than *Mycobacterium* species)).

Abscesses in intravenous drug users

Cutaneous abscesses frequently occur as a complication of injecting drug use. They commonly result from the use of non-sterile solutions in which the drug is dissolved or from lubrication of the needle using saliva.

Bacterial isolates include[44]:

- oral streptococci
- *Streptococcus anginosus* group
- *Fusobacterium nucleatum*
- *Prevotella species*
- *Porphyromonas* species
- *S. aureus*
- *Clostridium* species
- *Bacillus anthracis*
  (this is a rare but severe infection that can occur by injecting heroin contaminated with anthrax)[45]

Scalp abscess

Scalp abscesses are a recognised complication of electronic monitoring with fetal scalp electrodes during labour. A localised collection of pus surrounded by inflamed tissue forms where the electrodes are inserted. Anaerobes are most commonly isolated, probably as a result of contamination with vaginal organisms during delivery.

Polymicrobial infections also occur, involving[46]:

- anaerobes
- β-haemolytic streptococci
- *S. aureus*
- enterobacteriaceae
- enterococci
- coagulase negative staphylococci

Kerion is a pustular folliculitis of adjacent hair follicles, creating dense inflamed areas of the scalp, and is caused by dermatophytes (refer to B 39 – Investigation of dermatological specimens for superficial mycoses). Secondary bacterial infection may occur.

Ulcers

A skin ulcer is a lesion of the skin with loss of the skin integrity, which can extend from the epidermis down to deeper layers. There are various types of ulcers with different aetiology: pressure sores, diabetic foot ulcers, venous leg ulcers, arterial ulcers, autoimmune conditions such as pemphigus/pemphgoid. All ulcers are invariably colonised by a polymicrobial flora and microbiology samples should be taken only if a clinical diagnosis of infection has been made[47,48]. When swabs are taken from infected ulcers, they should be taken after cleansing and debridement: this aims at eliminating

part of the superficial colonising flora[48]. Sometimes chronic ulcer swabs are taken to identify the cause of underlying bone infections: in this scenario invasive bone biopsy specimens would be preferable, but ulcer swabs (after cleansing and debridement) are often taken in real practice but the results need careful interpretation[49].

Swabs from chronic non-healing ulcers or skin lesions with one of the following risk factors reported should be tested for *Corynebacterium* species:

- travel abroad to high risk area within the last 10 days
- contact with someone who has been to a high risk area within the last 10 days
- the patient works in a clinical microbiology laboratory, or similar occupation, where *Corynebacterium* species may be handled
- *Corynebacterium diphtheriae*, *Corynebacterium ulcerans* and *Corynebacterium pseudotuberculosis* can cause diphtheria and have been isolated from the skin of patients with chronic skin infections. For more information refer to ID 2 - Identification of *Corynebacterium* species)[21,50].

Burns[51,52]

Patients suffering from severe burns are at a higher risk of both local and systemic infection; sepsis is an important cause of mortality in this group of patients[51].

Organisms encountered include[51,53]:

- *S. aureus*
- β-haemolytic streptococci
- pseudomonads, especially *Pseudomonas aeruginosa*
- *Acinetobacter* species
- *Bacillus* species
- enterobacteriaceae
- filamentous fungi, eg: *Fusarium* species *and Aspergillus* species
- *Candida albicans,* non- *albicans Candida* species and other yeasts
- coagulase negative staphylococci

Gram negative organisms cause the most severe infections; fungal infections on the other hand can spread quickly, but are more easily treated, although a definitive diagnosis is difficult to obtain[51].

Bite wounds and contact with animals[4,54]

Bite wounds

Bite wounds can become contaminated by oral flora and normal human skin flora. Most bites are due to cats and dogs, but some are due to other pets (including reptiles, rodents and birds), domesticated animals (including horses, sheep etc) wild animals or other humans[4,54]. Organisms most commonly isolated include[4,55]:

- *Pasteurella multocida*
- *S. aureus*

- α-haemolytic streptococci
- streptococcus angiosus group

Other organisms associated with bite wounds which are rarely isolated include:

- anaerobes (including *Bacteriodes* species and Fusobacteria)
- *Capnocytophaga* species
- *Eikenella corrodens*
- *Haemophilus* species
- coagulase negative staphylococci
- *Streptobacillus moniliformis*
- *Staphylococcus intermedius*
- anaerobes (including Fusobacterium, Porphyromonas, Prerevotella etc)

Capnocytophaga canimorsus is associated with dog bites and causes septicaemia, particularly in patients with asplenia or underlying hepatic disease. This organism is usually isolated only from blood cultures.

Streptobacillus moniliformis is associated with rat bites and diagnosis is confirmed by culturing the organism from blood or joint fluid.

Other unusual organisms may be isolated including *Weeksella zoohelcum*, *Actinobacillus* species and *Neisseria canis*.

Insect bites are often associated with secondary Lancefield Group A streptococcus and *S. aureus* infection.

Contact with animals or animal products

Erysipeloid[56]

Erysipeloid is an uncommon nonsuppurative cellulitis due to *Erysipelothrix rhusiopathiae*. It is an occupational disease of fishermen, fish handlers, butchers and abattoir workers. It affects the hands and fingers causing lesions which present as painful purplish areas of inflammation with erythematous advancing edges.

Aeromonas and non-cholera *Vibrio* species

Aeromonas and non-cholera *Vibrio* species are predominantly isolated from traumatic water-related wounds or lacerations received whilst swimming in fresh or salt water, from other environmentally contaminated wounds, or from fishing or shellfish inflicted injuries[57-59]. Aeromonas infection may also follow the therapeutic use of leeches[60,61]. Water-related injuries can be polymicrobial involving environmental Gram negative organisms such as *Edwardsiella tarda* and pseudomonads[62].

Bacillus anthracis

Bacillus anthracis is the causative agent of anthrax which appears clinically in one of several forms; cutaneous (skin) anthrax or inhalation anthrax, as well as, more recently, injective anthrax[45]. Following the deliberate release of *B. anthracis* in the USA in 2001, there has been an increased awareness of the release of this and other organisms which may pose a biological threat. Cutaneous anthrax occurs through inoculation of spores to the skin or by contamination of abrasions. Skin lesions known

as malignant pustules develop, which are characteristic ulcers with a black centre[63]. They are rarely painful, but if untreated the infection can spread to cause septicaemia. If untreated, the disease can be fatal in 5% of cases, but with antibiotic treatment recovery is usual. Cutaneous infection with *B. anthracis* can occur in industrial workers who use materials of animal origin such as wool, leather, bristles and fur, or in the agricultural workplace for example farmers, husbandmen, butchers and vets. In rare cases *B. anthracis* has been transmitted via insect bites[64].

Other skin infections[4]

Skin infections may also be caused by the following:

- MRSA may colonise and/or infect wounds and soft tissue[65]. Newly emerging community (mecIV) MRSA with virulence factors such as Panton-Valentine Leukocidin (PVL) or Scalded Skin Toxin (SST) cause highly contagious infections such as follicultis in healthy children and young adults[66,67]. Infections are often spread through poor hygiene[68]. Panton-Valentine Leukocidin (PVL) is a toxin which is capable of destroying white blood cells[67]. Scalded skin syndrome (Lyell's syndrome in older children; Ritter's syndrome in infants) is caused by *S. aureus* phage types group II and 71[69]
- *Mycobacterium* species can cause cutaneous infections[70]. These may signify a disseminated systemic infection or may represent a local infection by non-tuberculous mycobacteria (see B 40 - Investigation of specimens for *Mycobacterium* species)
- rapid growing mycobacterial strains such as *M. chelonae* and *M. fortuitum* have also been isolated from superficial skin infections[71]. *M. chelonae* has been shown to be associated with tattoo related infections[72]
- *Sporothrix schenkii* causes sporotrichosis[73]. Cutaneous sporotrichosis is acquired by contamination with soil, sphagnum moss or other vegetable matter and develops at the site of inoculation to form a primary lesion with lymphatic spread (see B 39 - Investigation of dermatological specimens for superficial mycoses). It is more common in warmer climates
- cutaneous salmonellosis and listeriosis may also occur in veterinarians and farmers, typically on the arms, following assisted delivery of farm animals, usually cattle infected in utero[74,75]. Cutaneous listeriosis in a patient with AIDS has also been reported[76]
- *Yersinia enterocolitica* can cause cutaneous infections[77]

Technical information/limitations

Limitations of UK SMIs

The recommendations made in UK SMIs are based on evidence (eg sensitivity and specificity) where available, expert opinion and pragmatism, with consideration also being given to available resources. Laboratories should take account of local requirements and undertake additional investigations where appropriate. Prior to use, laboratories should ensure that all commercial and in-house tests have been validated and are fit for purpose.

Selective media in screening procedure

Selective media which does not support the growth of all circulating strains of organisms may be recommended based on the evidence available. A balance therefore must be sought between available evidence, and available resources required if more than one media plate is used.

Specimen containers[78,79]

SMIs use the term “CE marked leak proof container” to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: “The design must allow easy handling and, where necessary, reduce as far as possible contamination of and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes”.

Anaerobic plate incubation

The recommended incubation time for anaerobic plates is 48 hours. However some anaerobic bacteria such as certain species of *Actinomyces* require longer incubation (7 days) and will not be detected if plates are examined sooner.

Rapid methods

To reduce turnaround times, rapid identification and sensitivity tests may be performed in conjunction with routine methods where appropriate. A variety of rapid identification and sensitivity methods have been evaluated; these include molecular techniques and the Matrix Assisted Laser Desorption Ionisation Time-of-Flight (MALDI-TOF)[80]. It is important to ensure that fresh cultures of pure single isolates are tested to avoid reporting misleading results.

Laboratories should follow manufacturers’ instructions and all rapid tests must be validated and be shown to be fit for purpose prior to use.

1 Safety considerations[78,79,81-95]

1.1 Specimen collection, transport and storage[78,79,81-84]

Use aseptic technique.

Collect swabs into appropriate transport medium and transport in sealed plastic bags.

Compliance with postal, transport and storage regulations is essential.

1.2 Specimen processing[78,79,81-95]

Containment Level 2.

If infection with a Hazard Group 3 organism, eg *Bacillus anthracis* (cutaneous anthrax is rare but needs to be recognised as a possibility in certain settings such as exposure to animal hides, injection of contaminated heroin in IVDUs and bioterrorist events such as the dissemination of spores in letters that took place in the USA in 2001), all specimens must be processed in a microbiological safety cabinet under full Containment Level 3 conditions.

Laboratory procedures that give rise to infectious aerosols must be conducted in a microbiological safety cabinet[87].

Refer to current guidance on the safe handling of all organisms documented in this SMI.

The above guidance should be supplemented with local COSHH and risk assessments.

2 Specimen collection

2.1 Type of specimens

Skin swab, swab from superficial, non-surgical and surgical wounds, swabs of pus

2.2 Optimal time and method of collection[96]

For safety considerations refer to Section 1.1.

Collect specimens before starting antimicrobial therapy where possible[96,97].

Unless otherwise stated, swabs for bacterial and fungal culture should then be placed in appropriate transport medium[98-102].

Samples of pus/exudate, if present, are preferred to swabs (see B 14 – Investigation of deep-seated and organ, infections and abscesses). If only a minute amount of pus or exudate is available it is preferable to send a pus/exudate swab in transport medium to minimise the risk of desiccation during transport.

Sample a representative part of the lesion[97,103]. Swabbing dry crusted areas is unlikely to yield the causative pathogen[103].

If specimens are taken from ulcers, the debris on the ulcer should be removed and the ulcer should be cleaned with saline. A biopsy or, preferably, a needle aspiration of the edge of the wound should be taken[48].

A less invasive irrigation-aspiration method may be preferred. Place the tip of a small needleless syringe under the ulcer margin and irrigate gently with at least 1mL sterile

0.85% NaCl without preservative. After massaging the ulcer margin, repeat the irrigation with a further 1mL sterile saline. Massage the ulcer margin again, aspirate approximately 0.25mL of the fluid and place in a CE marked leak proof container[104].

Fungal specimens for dermatophytes: See B 39 - Investigation of dermatological specimens for superficial mycoses.

2.3 Adequate quantity and appropriate number of specimens[96]

Numbers and frequency of specimens collected are dependent on clinical condition of patient.

3 Specimen transport and storage[78,79]

3.1 Optimal transport and storage conditions

For safety considerations refer to Section 1.1.

Specimens should be transported and processed as soon as possible[96].

If processing is delayed, refrigeration is preferable to storage at ambient temperature[96].

4 Specimen processing/procedure[78,79]

4.1 Test selection

N/A

4.2 Appearance

N/A

4.3 Sample preparation

For safety considerations refer to Section 1.2.

4.3.1 Pre-treatment

N/A

4.3.2 Specimen processing

See Q 5 - Inoculation of culture media for bacteriology.

4.4 Microscopy

4.4.1 Standard

Gram stain is not normally required.

4.4.2 Supplementary

See B 40 - Investigation of specimens for *Mycobacterium* species, and TP 39 - Staining procedures.

4.5 Culture and investigation

Inoculate each agar plate directly by rolling the swab on a part of the plate or by using a sterile pipette (Q 5 - Inoculation of culture media for bacteriology).

For the isolation of individual colonies, spread inoculum with a sterile loop.

4.5.1 Culture media, conditions and organisms

Clinical details/ conditions	Specimen	Standard media	Incubation			Cultures read	Target organism(s)
			Temp °C	Atmos	Time		
All conditions	Swabs	Blood agar or Staph/Strep selective agar	35-37	5 -10% CO_2	40-48hr	Daily	Top pathogens: Lancefield Groups A, C and G streptococci *S. aureus* In specific circumstances e.g. bites or exposure to animals and animal products or fresh/salt water (use blood agar): *Pasteurella* species *Vibrio* species *Aeromona*s species *Bacillus cereus*/anthracis *Strep. pneumoniae* *Eikenella corrodens* Capnocytophaga Erysipelothrix
		CLED/MacConkey agar	35-37	Air	18-24hr	>18hr	Clinical circumstances determines significance of the following isolates Enterobacteriaceae Pseudomonads
For these situations, add the following:							
Clinical details/ conditions	**Specimen**	**Supplementary media**	**Incubation**			**Cultures read**	**Target organism(s)**
			Temp °C	**Atmos**	**Time**		
Wound swabs eg traumatic wounds Swabs of pus	Swabs	Selective anaerobe agar with metronidazole 5µg disc	35-37	Anaerobic	5d	≥40hr+ and at 5 d	Anaerobes
Swab of pus	Swabs	Fastidious anaerobic, cooked meat broth or equivalent Subculture to BA if evidence of growth (≥40hr), or at day 5	35-37 35-37	Air 5 -10% CO_2	5d 40-48hr	N/A daily	Any organism
Cellulitis in children Human bites	Swabs	Chocolate agar †	35-37	5-10% CO_2	40-48hr	daily	Fastidious organisms *Haemophilus* species

Burns Patients who are Immunocompromised Diabetic patients Intertrigo Paronychia	Swabs	Sabouraud agar	28-30	Air	14 d	daily	Yeast Mould
Suspected cutaneous diphtheria (Consider for foreign travel with <10 d and non-healing ulcers)	Swabs	Hoyle's tellurite agar	35-37	Air	40-48hr	daily	*C. diphtheriae* *C. ulcerans*
Other organisms for consideration: Dermatophytes (B 39 - Investigation of dermatological specimens for superficial mycoses) and *Mycobacterium* species (B 40 - Investigation of specimens for *Mycobacterium* species)							
[+] Some anaerobic bacteria such as certain species of Actinomyces require longer incubation (7 days) and will not be detected if plates are examined sooner. † Either bacitracin 10 unit disc or bacitracin - containing agar may be used.							

4.5.2 Supplementary investigations

Toxigenicity testing of *C. diphtheriae.*

See B 40 - Investigation of specimens for *Mycobacterium* species.

4.6 Identification

Refer to individual SMIs for organism identification.

4.6.1 Minimum level of identification in the laboratory

Aeromonas	species level
Anaerobes	anaerobes level except in necrotising infections
Bacillus species	species level when appropriate to diagnose or exclude *B. anthracis* or *B. cereus* infections
β-haemolytic streptococci	Lancefield Group level
Coagulase negative staphylococci	coagulase negative level
C. diphtheriae	species level and urgent (same-day) toxigenicity test (when appropriate clinical details)
C. minutissimum	species level in erythrasma
C. ulcerans	species level (when appropriate clinical details)
Dermatophytes	B 39 - Investigation of dermatological specimens for superficial mycoses
E. corrodens	species level
Enterobacteriaceae	coliforms level except in necrotising infections

E. rhusiopathiae	species level
Haemophilus	species level
Mould	genus level
Pasteurella	species level
Pseudomonads	Usually only at pseudomonads level except in echtyma gangrenosum, recreational water folliculitis, necrotising infections, burns
S. aureus	species level (consider Panton-Valentine leukocidin (PVL) and toxin testing if appropriate clinical details)
S. pneumoniae	species level
Yeasts	yeasts level
Vibrio	species level

Organisms may be further identified if this is clinically or epidemiologically indicated.

Note: All work on suspected isolates of *C. diphtheriae* which is likely to generate aerosols must be performed in a safety cabinet[85].

A medical microbiologist must be informed of all suspected isolates of *C. diphtheriae* as soon as possible (same-day toxigenicity testing is available from the reference laboratory).

4.7 Antimicrobial susceptibility testing

Refer to British Society for Antimicrobial Chemotherapy (BSAC), EUCAST and/or CSLI guidelines or manufacturer's validation for proprietary methods.

This SMI recommends selective and restrictive reporting of susceptibilities to antimicrobials. Any deviation must be subject to consultation that should include local antimicrobial stewardship groups.

4.7.1 Antimicrobial susceptibility testing and reporting table

It is recommended that the antimicrobials in bold in the table below are reported. Those antimicrobials not in bold may be reported based on local decisions.

For more information on Detection of bacteria with Carbapenem-Hydrolysing β-lactamases (Carbapenemases) refer to B 60.

Bacteria	**Examples of agents to be included within primary test panel (recommended agents to be reported are in bold depending on clinical presentation)**	**Examples of agents to be considered for supplementary testing (recommended agents to be reported are in bold depending on clinical presentation)**	**Notes**
S. aureus	**Cefoxitin[1] (or Oxacillin)** **Erythromycin/ Clarithromycin** **Tetracycline[2]**	Clindamycin Co-trimoxazole Daptomycin Fusidic acid Gentamicin Linezolid Mupirocin Penicillin Rifampicin Teicoplanin Vancomycin	1. Report as Flucloxacillin. 2. Supress report in children.
Pyogenic Streptococci	**Erythromycin/ Clarithromycin** **Penicillin** **Tetracycline[2]**	Clindamycin Co-trimoxazole Linezolid Vancomycin	2. Supress report in children.
Enterobacteriaceae from clean surgical sites	Ampicillin (or Amoxicillin) Cefpodoxime[4] Co-amoxiclav[5] Gentamicin	Amikacin Aztreonam Cefotaxime (or Ceftriaxone) Ceftazidime Cefuroxime Ciprofloxacin Co-trimoxazole Ertapenem Meropenem (or Imipenem) Piperacillin/Tazobactam Temocillin	3. Antibiotics should only be reported in the presence of clinical evidence of infection. 4. Cefpodoxime resistant organisms should be tested for the presence of ESBLs and screened for reduced susceptibility to carbapenems. 5. Co-amoxiclav resistant organisms should be tested at local level for sensitivity to carbapenems.

Enterobacteriaceae from sites prone to colonisation (eg ulcers)		Amikacin Ampicillin (or Amoxicillin) Aztreonam Cefpodoxime[4, 6] Cefuroxime Ciprofloxacin Ceftazidime Cefotaxime (or Ceftriaxone) Co-amoxiclav[5, 6] Cotrimoxazole Ertapenem Gentamicin Meropenem (or Imipenem) Piperacillin/Tazobactam Temocillin	4. Cefpodoxime resistant organisms should be tested for the presence of ESBLs and screened for reduced susceptibility to carbapenems. 5. Co-amoxiclav resistant organisms should be tested at local level for sensitivity to carbapenems. 6. If susceptibility testing is being undertaken, include this agent.
Pseudomonads		Amikacin Ceftazidime Ciprofloxacin Gentamicin Meropenem (or Imipenem) Piperacillin/Tazobactam	

4.8 Referral for outbreak investigations

N/A

4.9 Referral to reference laboratories

For information on the tests offered, turnaround times, transport procedure and the other requirements of the reference laboratory click here for user manuals and request forms.

Organisms with unusual or unexpected resistance, or associated with a laboratory or clinical problem, or anomaly that requires elucidation should be sent to the appropriate reference laboratory.

Contact appropriate devolved national reference laboratory for information on the tests available, turnaround times, transport procedure and any other requirements for sample submission:

England and Wales

https://www.gov.uk/specialist-and-reference-microbiology-laboratory-tests-and-services

Scotland

http://www.hps.scot.nhs.uk/reflab/index.aspx

Northern Ireland

http://www.publichealth.hscni.net/directorate-public-health/health-protection

5 Reporting procedure

5.1 Microscopy

Standard

Gram stain (not usually required)

Report on WBCs and organisms detected.

Supplementary

For the reporting of microscopy for *Mycobacterium* species refer to B 40 – Investigation of specimens for *Mycobacterium* species.

5.1.1 Microscopy reporting time

All results should be issued to the requesting clinician as soon as they become available, unless specific alternative arrangements have been made with the requestors.

Urgent results should be telephoned or transmitted electronically in accordance with local policies.

5.2 Culture

Following results should be reported:

- clinically significant organisms isolated
- other growth
- absence of growth

5.2.1 Culture reporting time

Interim or preliminary results should be issued on detection of potentially clinically significant isolates as soon as growth is detected, unless specific alternative arrangements have been made with the requestors.

Urgent results should be telephoned or transmitted electronically in accordance with local policies.

Final written or computer generated reports should follow preliminary and verbal reports as soon as possible.

5.3 Antimicrobial susceptibility testing

Report susceptibilities as clinically indicated. Prudent use of antimicrobials according to local and national protocols is recommended.

Refer to table 4.7.1. The table includes guidance on the minimum range of agents that should be tested on the bacterial isolates listed. The table also includes additional agents that can be considered for inclusion in test panels in specific clinical scenarios.

Any deviation from the guidance should be subject to local consultation and risk assessment.

Generally, all resistant results should be reported as this is good practice and informs the user.

6 Notification to PHE[105,106], or equivalent in the devolved administrations[107-110]

The Health Protection (Notification) regulations 2010 require diagnostic laboratories to notify Public Health England (PHE) when they identify the causative agents that are listed in Schedule 2 of the Regulations. Notifications must be provided in writing, on paper or electronically, within seven days. Urgent cases should be notified orally and as soon as possible, recommended within 24 hours. These should be followed up by written notification within seven days.

For the purposes of the Notification Regulations, the recipient of laboratory notifications is the local PHE Health Protection Team. If a case has already been notified by a registered medical practitioner, the diagnostic laboratory is still required to notify the case if they identify any evidence of an infection caused by a notifiable causative agent.

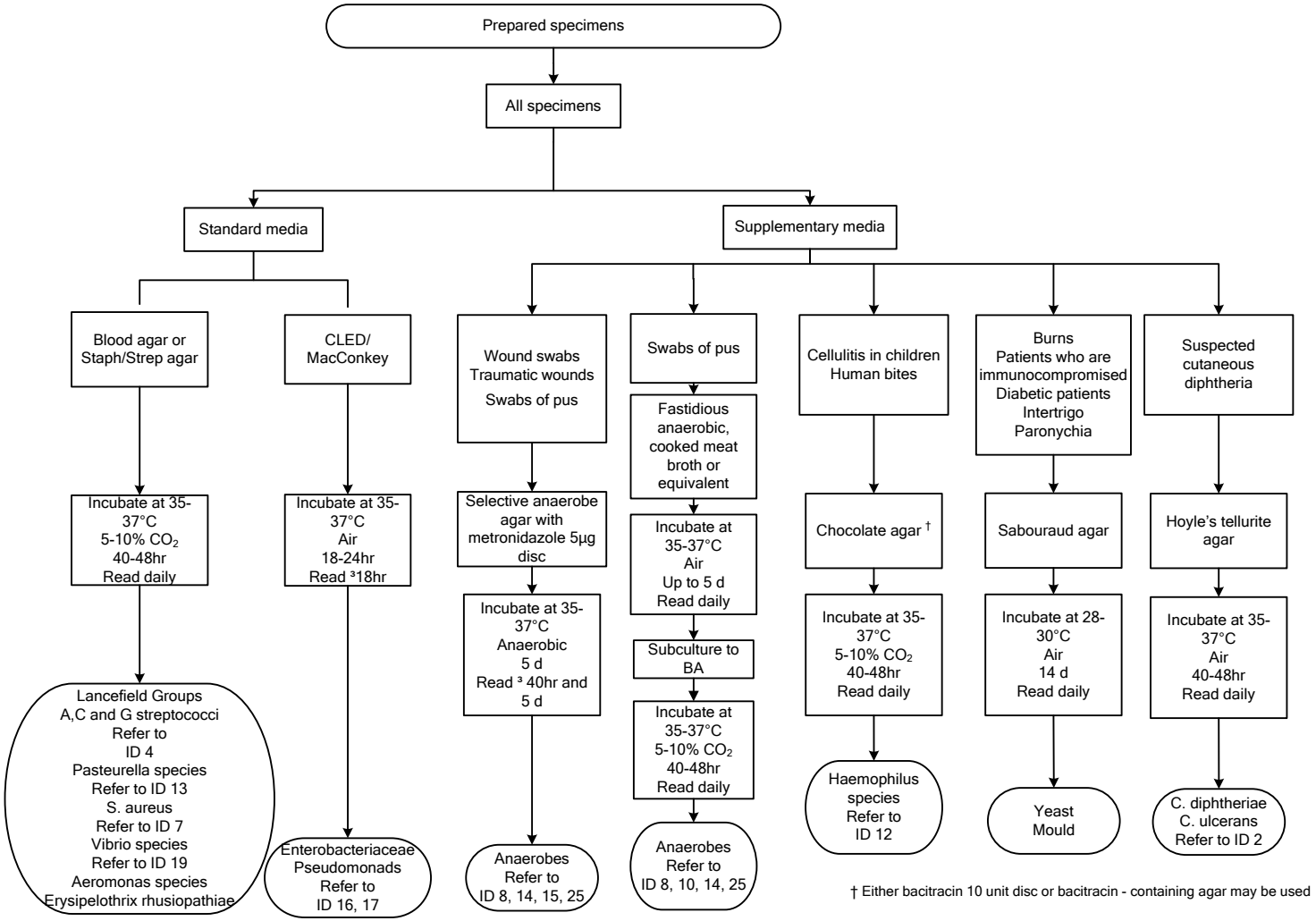
Notification under the Health Protection (Notification) Regulations 2010 does not replace voluntary reporting to PHE. The vast majority of NHS laboratories voluntarily report a wide range of laboratory diagnoses of causative agents to PHE and many PHE Health protection Teams have agreements with local laboratories for urgent reporting of some infections. This should continue.

Note: The Health Protection Legislation Guidance (2010) includes reporting of Human Immunodeficiency Virus (HIV) & Sexually Transmitted Infections (STIs), Healthcare Associated Infections (HCAIs) and Creutzfeldt–Jakob disease (CJD) under 'Notification Duties of Registered Medical Practitioners': it is not noted under 'Notification Duties of Diagnostic Laboratories'.

https://www.gov.uk/government/organisations/public-health-england/about/our-governance#health-protection-regulations-2010

Other arrangements exist in Scotland[107,108], Wales[109] and Northern Ireland[110].

Appendix: Investigation of skin and superficial soft tissue infections



References

1. Fenech M, Abela R, Chetcuti Zammit S, Mercieca L, Gauci J, Edwards N et al. Wound swab use and misuse at a regional general hospital. Journal of wound care 2014;23:634-42.

2. Dryden MS. Complicated skin and soft tissue infection. JAntimicrobChemother 2010;65 Suppl 3:iii35-iii44.

3. Koerner R, Johnson AP. Changes in the classification and management of skin and soft tissue infections. JAntimicrobChemother 2011;66:232-4.

4. Stevens DL, Bisno AL, Chambers HF, Everett ED, Dellinger P, Goldstein EJ et al. Practice guidelines for the diagnosis and management of skin and soft-tissue infections. ClinInfectDis 2005;41:1373-406.

5. Stevens DL, Bisno AL, Chambers HF, Dellinger EP, Goldstein EJ, Gorbach SL et al. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the Infectious Diseases Society of America. ClinInfectDis 2014;59:e10-e52.

6. Goodyear H. Infections and infestations of the skin. Paediatrics and Child Health 2014;25:72-7.

7. Concheiro J, Loureiro M, Gonzalez-Vilas D, Garcia-Gavin J, Sanchez-Aguilar D, Toribio J. [Erysipelas and cellulitis: a retrospective study of 122 cases]. Actas Dermosifiliogr 2009;100:888-94.

8. Gunderson CG, Martinello RA. A systematic review of bacteremias in cellulitis and erysipelas. JInfect 2012;64:148-55.

9. Wilson ML, Winn W. Laboratory diagnosis of bone, joint, soft-tissue, and skin infections. ClinInfectDis 2008;46:453-7.

10. Gunderson CG. Cellulitis: definition, etiology, and clinical features. AmJMed 2011;124:1113-22.

11. Meredith FT, Fowler VG, Gautier M, Corey GR, Reller LB. Bacillus cereus necrotizing cellulitis mimicking clostridial myonecrosis: case report and review of the literature. [Review] [9 refs]. Scandinavian Journal of Infectious Diseases 1997;29:528-9.

12. Giacometti A, Cirioni O, Schimizzi AM, Del Prete MS, Barchiesi F, D'Errico MM et al. Epidemiology and microbiology of surgical wound infections. J Clin Microbiol 2000;38:918-22.

13. Turner DP, Nagra RS, Large S, Seaton D. Recurrent cellulitis following coronary bypass surgery. J Hosp Infect 1995;30:78-80.

14. Raju S, Tackett P, Jr., Neglen P. Spontaneous onset of bacterial cellulitis in lower limbs with chronic obstructive venous disease. EurJVascEndovascSurg 2008;36:606-10.

15. Solowski NL, Yao FB, Agarwal A, Nagorsky M. Ecthyma gangrenosum: a rare cutaneous manifestation of a potentially fatal disease. AnnOtolRhinolLaryngol 2004;113:462-4.

16. Bin Abdulhak AA, Zimmerman V, Al Beirouti BT, Baddour LM, Tleyjeh IM. Stenotrophomonas maltophilia infections of intact skin: a systematic review of the literature. DiagnMicrobiolInfectDis 2009;63:330-3.

17. Anaissie E. Opportunistic mycoses in the immunocompromised host: experience at a cancer center and review. [Review] [130 refs]. Clin Infect Dis 1992;14 Suppl 1:43-53.

18. Ginsburg CM. Staphylococcal toxin syndromes. Pediatr Infect Dis J 1991;10:319-21.

19. Brook I, Frazier EH, Yeager JK. Microbiology of nonbullous impetigo. Pediatr Dermatol 1997;14:192-5.

20. Celestin R, Brown J, Kihiczak G, Schwartz RA. Erysipelas: a common potentially dangerous infection. Acta DermatovenerolAlp PanonicaAdriat 2007;16:123-7.

21. Blaise G, Nikkels AF, Hermanns-Le T, Nikkels-Tassoudji N, Pierard GE. Corynebacterium-associated skin infections. IntJDermatol 2008;47:884-90.

22. Garber G. An overview of fungal infections. [Review] [89 refs]. Drugs 2001;61 Suppl 1:1-12.

23. Rockwell PG. Acute and chronic paronychia. [Review] [11 refs]. Amer Fam Physic 2001;63:1113-6.

24. Otberg N, Kang H, Alzolibani AA, Shapiro J. Folliculitis decalvans. DermatolTher 2008;21:238-44.

25. Tate D, Mawer S, Newton A. Outbreak of Pseudomonas aeruginosa folliculitis associated with a swimming pool inflatable. EpidemiolInfect 2003;130:187-92.

26. Ratnam S, Hogan K, March SB, Butler RW. Whirlpool-associated folliculitis caused by Pseudomonas aeruginosa: report of an outbreak and review. [Review] [46 refs]. J Clin Microbiol 1986;23:655-9.

27. Fiorillo L, Zucker M, Sawyer D, Lin AN. The pseudomonas hot-foot syndrome.[comment]. N Engl J Med 2001;345:335-8.

28. Frenkel LM. Pseudomonas folliculitis from sponges promoted as beauty aids.[comment]. J Clin Microbiol 1993;31:2838.

29. Akaza N, Akamatsu H, Sasaki Y, Kishi M, Mizutani H, Sano A et al. Malassezia folliculitis is caused by cutaneous resident Malassezia species. MedMycol 2008:1-7.

30. Difonzo EM, Faggi E. Skin diseases associated with Malassezia species in humans. Clinical features and diagnostic criteria. Parassitologia 2008;50:69-71.

31. Anaya DA, Dellinger EP. Necrotizing soft-tissue infection: diagnosis and management. ClinInfectDis 2007;44:705-10.

32. Sawyer MD, Dunn DL. Deep soft-tissue infections. Curr Opinion Infect Dis 1991;4:649-54.

33. Voros D, Pissiotis C, Georgantas D, Katsaragakis S, Antoniou S, Papadimitriou J. Role of early and extensive surgery in the treatment of severe necrotizing soft tissue infection. BrJSurg 1993;80:1190-1.

34. Kingston D, Seal DV. Current hypotheses on synergistic microbial gangrene. BrJSurg 1990;77:260-4.

35. Safioleas M, Stamatakos M, Mouzopoulos G, Diab A, Kontzoglou K, Papachristodoulou A. Fournier's gangrene: exists and it is still lethal. Int UrolNephrol 2006;38:653-7.

36. Dylewski J, Drummond R, Rowen J. A case of Clostridium septicum spontaneous gas gangrene. CJEM 2007;9:133-5.

37. Rekha A, Ravi A. A retrospective study of necrotising fasciitis. Int JLow ExtremWounds 2003;2:46-9.

38. Puvanendran R, Huey JC, Pasupathy S. Necrotizing fasciitis. CanFamPhysician 2009;55:981-7.

39. Crum-Cianflone NF. Bacterial, fungal, parasitic, and viral myositis. ClinMicrobiolRev 2008;21:473-94.

40. Lichon V, Khachemoune A. Mycetoma : a review. AmJClinDermatol 2006;7:315-21.

41. Welsh O, Vera-Cabrera L, Salinas-Carmona MC. Mycetoma. ClinDermatol 2007;25:195-202.

42. Revankar SG, Sutton DA. Melanized fungi in human disease. ClinMicrobiolRev 2010;23:884-928.

43. Rattanavong S, Vongthongchit S, Bounphamala K, Vongphakdy P, Gubler J, Mayxay M et al. Actinomycetoma in SE Asia: the first case from Laos and a review of the literature. BMCInfectDis 2012;12:349.

44. Brook I. The role of anaerobic bacteria in cutaneous and soft tissue abscesses and infected cysts. Anaerobe 2007;13:171-7.

45. Abbara A, Brooks T, Taylor GP, Nolan M, Donaldson H, Manikon M et al. Lessons for control of heroin-associated anthrax in Europe from 2009-2010 outbreak case studies, London, UK. Emerging infectious diseases 2014;20:1115-22.

46. Brook I, Frazier EH. Microbiology of scalp abscess in newborns. PediatrInfectDisJ 1992;11:766-8.

47. Bowler PG, Duerden BI, Armstrong DG. Wound microbiology and associated approaches to wound management. ClinMicrobiolRev 2001;14:244-69.

48. Lipsky BA, Berendt AR, Cornia PB, Pile JC, Peters EJ, Armstrong DG et al. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. ClinInfectDis 2012;54:e132-e73.

49. Senneville E, Melliez H, Beltrand E, Legout L, Valette M, Cazaubiel M et al. Culture of percutaneous bone biopsy specimens for diagnosis of diabetic foot osteomyelitis: concordance with ulcer swab cultures. ClinInfectDis 2006;42:57-62.

50. Wagner J, Ignatius R, Voss S, Hopfner V, Ehlers S, Funke G et al. Infection of the skin caused by Corynebacterium ulcerans and mimicking classical cutaneous diphtheria. Clin Infect Dis 2001;33:1598-600.

51. Branski LK, Al-Mousawi A, Rivero H, Jeschke MG, Sanford AP, Herndon DN. Emerging infections in burns. SurgInfect(Larchmt) 2009;10:389-97.

52. Taneja N, Chari P, Singh M, Singh G, Biswal M, Sharma M. Evolution of bacterial flora in burn wounds: key role of environmental disinfection in control of infection. International journal of burns and trauma 2013;3:102-7.

53. Revathi G, Puri J, Jain BK. Bacteriology of burns. Burns 1998;24:347-9.

54. Abrahamian FM, Goldstein EJ. Microbiology of animal bite wound infections. ClinMicrobiolRev 2011;24:231-46.

55. Frans J, Verhaegen J, Van Noyen R. Streptobacillus moniliformis: case report and review of the literature. Acta ClinBelg 2001;56:187-90.

56. Wang Q, Chang BJ, Riley TV. Erysipelothrix rhusiopathiae. Veterinary microbiology 2010;140:405-17.

57. Gold WL, Salit IE. Aeromonas hydrophila infections of skin and soft tissue: report of 11 cases and review. [Review] [47 refs]. Clin Infect Dis 1993;16:69-74.

58. Hartley JW, West E, Gothard WP, Hanan HW. Vibrio alginolyticus in the U.K. J Infect 1991;23:223.

59. Janda JM, Abbott SL. Evolving concepts regarding the genus Aeromonas: an expanding Panorama of species, disease presentations, and unanswered questions. [Review] [122 refs]. Clin Infect Dis 1998;27:332-44.

60. Fenollar F, Fournier PE, Legre R. Unusual case of Aeromonas sobria cellulitis associated with the use of leeches. E J Clin Microbiol Infect Dis 1999;18:72-3.

61. Sartor C, Limouzin-Perotti F, Legre R, Casanova D, Bongrand MC, Sambuc R et al. Nosocomial infections with Aeromonas hydrophila from leeches. Clin Infect Dis 2002;35:E1-E5.

62. Vartian CV, Septimus EJ. Soft-tissue infection caused by Edwardsiella tarda and Aeromonas hydrophila. J Infect Dis 1990;161:816.

63. Tutrone WD, Scheinfeld NS, Weinberg JM. Cutaneous anthrax: a concise review. [Review] [27 refs]. Cutis 2002;69:27-33.

64. Bradaric N, Punda-Polic V. Cutaneous anthrax due to penicillin-resistant Bacillus anthracis transmitted by an insect bite. Lancet 1992;340:306-7.

65. Ray GT, Suaya JA, Baxter R. Microbiology of skin and soft tissue infections in the age of community-acquired methicillin-resistant Staphylococcus aureus. DiagnMicrobiolInfectDis 2013;76:24-30.

66. Dryden M. Complicated skin and soft tissue infections caused by methicillin-resistant Staphylococcus aureus: epidemiology, risk factors, and presentation. SurgInfect(Larchmt) 2008;9 Suppl 1:s3-10.

67. Health Protection Agency, PVL sub-group of the Streering Group on Healthcare Associated Infection. Guidance on the diagnosis and management of PVL-assocaited Staphylococcus aureus infections (PVL-SA) in England. 2nd Edition 2008. 1-49.

68. Whitman TJ. Community-associated methicillin-resistant Staphylococcus aureus skin and soft tissue infections. DisMon 2008;54:780-6.

69. Ladhani S, Joannou CL, Lochrie DP, Evans RW, Poston SM. Clinical, microbial, and biochemical aspects of the exfoliative toxins causing staphylococcal scalded-skin syndrome. [Review] [290 refs]. Clin Microbiol Rev 1999;12:224-42.

70. Weitzul S, Eichhorn PJ, Pandya AG. Non-tuberculous mycobacterial infections of the skin. [Review] [85 refs]. Dermatol Clinics 2000;18:359-77.

71. Kothavade RJ, Dhurat RS, Mishra SN, Kothavade UR. Clinical and laboratory aspects of the diagnosis and management of cutaneous and subcutaneous infections caused by rapidly growing mycobacteria. EurJClinMicrobiolInfectDis 2013;32:161-88.

72. Conglen PD, Laurenson IF, Sergeant A, Thorn SN, Rayner A, Stevenson J. Systematic review of Tattoo-Associated Skin Infection with Rapidely Growing Mycobacteria and Public Health Investigation of a Cluster in Scotland, 2010. Eurosurveillance 2013;18.

73. Chakrabarti A, Bonifaz A, Gutierrez-Galhardo MC, Mochizuki T, Li S. Global epidemiology of sporotrichosis. Medical mycology 2015;53:3-14.

74. McLauchlin J, Low JC. Primary cutaneous listeriosis in adults: an occupational disease of veterinarians and farmers. VetRec 1994;135:615-7.

75. Cain DB, McCann VL. An unusual case of cutaneous listeriosis. JClinMicrobiol 1986;23:976-7.

76. Vasquez A, Ramos JM, Pacho E, Rodriguez-Perez A, Cuenca-Estrella M, Esteban J. Cutaneous listeriosis in a patient infected with the human immunodeficiency virus. ClinInfectDis 1994;19:988-9.

77. Krogstad P, Mendelman PM, Miller VL, Clausen C, Abbott S, Weagant S et al. Clinical and microbiologic characteristics of cutaneous infection with Yersinia enterocolitica. J Infect Dis 1992;165:740-3.

78. European Parliament. UK Standards for Microbiology Investigations (SMIs) use the term "CE marked leak proof container" to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: "The design must allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes". 1998.

79. Official Journal of the European Communities. Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on *in vitro* diagnostic medical devices 1998. 1-37.

80. Clark AE, Kaleta EJ, Arora A, Wolk DM. Matrix-assisted laser desorption ionization-time of flight mass spectrometry: a fundamental shift in the routine practice of clinical microbiology. ClinMicrobiolRev 2013;26:547-603.

81. Health and Safety Executive. Safe use of pneumatic air tube transport systems for pathology specimens. 2009.

82. Department for transport. Transport of Infectious Substances, 2011 Revision 5. 2011.

83. World Health Organization. Guidance on regulations for the Transport of Infectious Substances 2013-2014. 2012.

84. Home Office. Anti-terrorism, Crime and Security Act. 2001.

85. Advisory Committee on Dangerous Pathogens. The Approved List of Biological Agents. Health and Safety Executive 2013. 1-32.

86. Advisory Committee on Dangerous Pathogens. Infections at work: Controlling the risks. Her Majesty's Stationery Office 2003.

87. Advisory Committee on Dangerous Pathogens. Biological agents: Managing the risks in laboratories and healthcare premises. Health and Safety Executive 2005.

88. Advisory Committee on Dangerous Pathogens. Biological Agents: Managing the Risks in Laboratories and Healthcare Premises. Appendix 1.2 Transport of Infectious Substances - Revision. Health and Safety Executive 2008.

89. Centers for Disease Control and Prevention. Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. MMWR Surveill Summ 2012;61:1-102.

90. Health and Safety Executive. Control of Substances Hazardous to Health Regulations. The Control of Substances Hazardous to Health Regulations 2002. 5th ed.: HSE Books; 2002.

91. Health and Safety Executive. Five Steps to Risk Assessment: A Step by Step Guide to a Safer and Healthier Workplace. HSE Books. 2002.

92. Health and Safety Executive. A Guide to Risk Assessment Requirements: Common Provisions in Health and Safety Law. HSE Books. 2002.

93. Health Services Advisory Committee. Safe Working and the Prevention of Infection in Clinical Laboratories and Similar Facilities. HSE Books 2003.

94. British Standards Institution (BSI). BS EN12469 - Biotechnology - performance criteria for microbiological safety cabinets 2000.

95. British Standards Institution (BSI). BS 5726:2005 - Microbiological safety cabinets. Information to be supplied by the purchaser and to the vendor and to the installer, and siting and use of cabinets. Recommendations and guidance. 2005. 1-14.

96. Baron EJ, Miller JM, Weinstein MP, Richter SS, Gilligan PH, Thomson RB, Jr. et al. A Guide to Utilization of the Microbiology Laboratory for Diagnosis of Infectious Diseases: 2013 Recommendations by the Infectious Diseases Society of America (IDSA) and the American Society for Microbiology (ASM). ClinInfectDis 2013;57:e22-e121.

97. Cross HH. Obtaining a wound swab culture specimen. Nursing 2014;44:68-9.

98. Rishmawi N, Ghneim R, Kattan R, Ghneim R, Zoughbi M, Abu-Diab A et al. Survival of fastidious and nonfastidious aerobic bacteria in three bacterial transport swab systems. JClinMicrobiol 2007;45:1278-83.

99. Barber S, Lawson PJ, Grove DI. Evaluation of bacteriological transport swabs. Pathology 1998;30:179-82.

100. Van Horn KG, Audette CD, Sebeck D, Tucker KA. Comparison of the Copan ESwab system with two Amies agar swab transport systems for maintenance of microorganism viability. JClinMicrobiol 2008;46:1655-8.

101. Nys S, Vijgen S, Magerman K, Cartuyvels R. Comparison of Copan eSwab with the Copan Venturi Transystem for the quantitative survival of *Escherichia coli, Streptococcus agalactiae* and *Candida albicans*. EurJClinMicrobiolInfectDis 2010;29:453-6.

102. Tano E, Melhus A. Evaluation of three swab transport systems for the maintenance of clinically important bacteria in simulated mono- and polymicrobial samples. APMIS 2011;119:198-203.

103. Al Ghazal P, Korber A, Klode J, Schmid EN, Buer J, Dissemond J. Evaluation of the Essen Rotary as a new technique for bacterial swabs: results of a prospective controlled clinical investigation in 50 patients with chronic leg ulcers. International wound journal 2014;11:44-9.

104. Ehrenkranz NJ, Alfonso B, Nerenberg D. Irrigation-aspiration for culturing draining decubitus ulcers: correlation of bacteriological findings with a clinical inflammatory scoring index. J Clin Microbiol 1990;28:2389-93.

105. Public Health England. Laboratory Reporting to Public Health England: A Guide for Diagnostic Laboratories 2013. 1-37.

106. Department of Health. Health Protection Legislation (England) Guidance. 1-112. 2010.

107. Scottish Government. Public Health (Scotland) Act. 2008.

108. Scottish Government. Public Health etc. (Scotland) Act 2008. Implementation of Part 2: Notifiable Diseases, Organisms and Health Risk States. 2009.

109. The Welsh Assembly Government. Health Protection Legislation (Wales) Guidance. 2010.

110. Home Office. Public Health Act (Northern Ireland) 1967 Chapter 36. 1967.