Identification of variables for aerobic bacterial density at clinically relevant skin sites☆

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SUMMARY

In studies on efficacy testing of topical antimicrobial products, randomisation of test areas and a well-balanced gender ratio are not always standard. Our aim was to generate an evidence-based skin flora map using a systematic review of the literature supplemented by *in vivo* tests to identify variables that impact on microbial density. Ten out of 83 evaluated studies were reviewed. Microbial density was higher on sebaceous-rich and wet skin sites. In the *in vivo* study the forehead, upper back, lumbar area, and abdomen of 180 subjects were sampled with a standardised swab method. The highest aerobic microbial density was found on the forehead (mean $\log_{10}$ cfu/cm^2 = 3.69 ± 1.00), followed by the upper back (3.00 ± 0.90), the abdomen (2.98 ± 0.74), and the lumbar area (2.35 ± 0.70). The difference between all four skin sites was significant ($P < 0.001$; analysis of variance). On the forehead, we found significantly more micro-organisms on the medial compared to the lateral side ($P = 0.002$; t-test), on the upper back we found more micro-organisms cranially than caudally ($P = 0.006$). Males carried significantly more micro-organisms on all sites ($P < 0.001$). Randomisation of the test areas is essential to obtain representative results in studies on the density of skin flora or the efficacy of skin antiseptics. A well-balanced gender ratio is also strongly recommended for any study population.

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Introduction

The human skin represents the most important protective barrier to microbes; however, it harbours a diversity of micro-organisms and is therefore a potential source of endogenous infections, e.g. catheter-related bacteraemias or surgical site infections. Nosocomial infections can be caused by aerobic micro-organisms from the human skin, e.g. coagulase-negative staphylococci and *Staphylococcus aureus*.[1–4]

Different areas of the skin are not similarly covered by aerobic and anaerobic micro-organisms.[5] Both their quantity and quality depend significantly on the skin site and vary significantly both intra- and inter-individually.[6–11]

There are many studies of human skin microbial flora in the literature; however, the results are often not comparable due to use of different sampling methods.[12] Furthermore, the presentation of results varies and descriptions of test methods may lack significant details.

Whenever representative results on human skin flora are required, for example in antiseptic efficacy testing, tests on different sites are recommended.[13–15] However, these differ in the USA and Europe. The Food and Drug Administration (FDA) recommends tests on dry (abdomen) and moist (groin) skin sites.[14] The American Society for Testing and Materials (ASTM) prefers the inguinal region, the clavicular region and the cubital fossa.[13] In Germany, the standard test sites are the upper arms and forehead.[16] These differences must be taken into consideration; we have already shown that the chosen skin site significantly influences the antiseptic efficacy test results.[15]
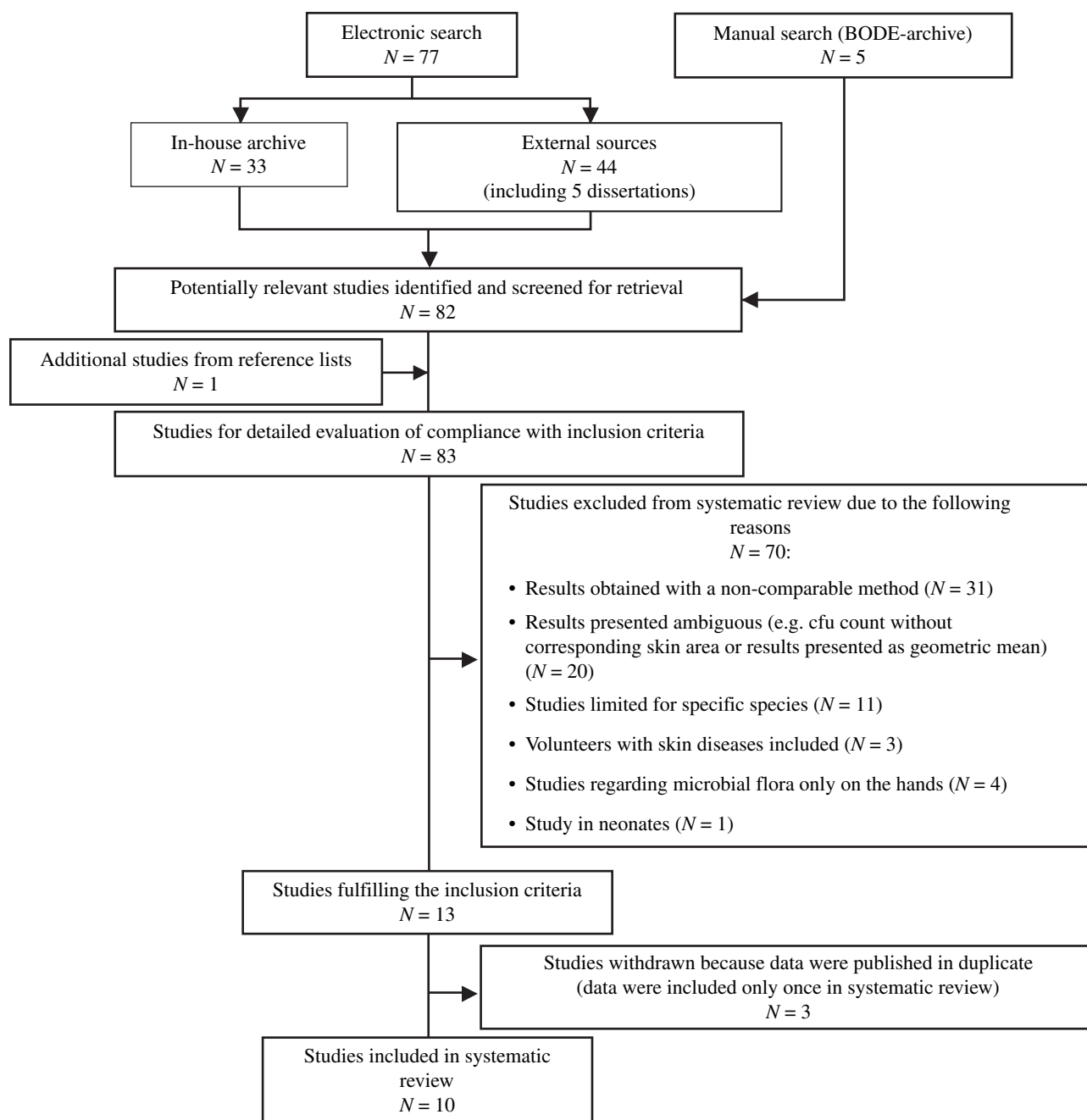
Figure 1. Study selection process for systematic review.

The aim of the first part of this study was to generate an evidence-based skin flora map quantifying aerobic micro-organisms on human skin by a systematic review of published data. Based on this map we chose four clinically relevant skin sites to analyse the differences in skin flora density *in vivo* and to identify variables that impact on microbial density.

Methods

Systematic review

Publications of experimental *in vivo* studies for the systematic review were searched electronically and manually by a scientific investigator. Our search was limited to English and German

publications and was performed between April and August 2006. The electronic search was carried out using PubMed for searching in the MEDLINE database (from 1950 to 2006). In addition, we electronically searched all publications published up to August 2006 in the Campus Catalogue Hamburg (Staats- und Universitätsbibliothek Hamburg Carl von Ossietzky; University of Hamburg), the Common Library Network GBV and the online publication server OPUS (University of Hamburg). The following keywords were used: 'skin bacteria', 'cutaneous microflora'; 'skin flora'; 'skin microbiology', 'skin disinfection', 'skin antisepsis'. The keywords were used with and without double quotes. PubMed applies an AND operator between concepts; no other Boolean operators were used. We also manually searched the publication archive of BODE Chemie GmbH (Hamburg) for all studies regarding