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Hospitalization cost at childbirth: Health parameters and colonization with antimicrobial resistant bacteria and methicillin susceptible *Staphylococcus aureus*

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ABSTRACT

Objective: Antimicrobial resistant bacteria (AMR) are of public health and economic relevance. However, there is a lack of data regarding AMR colonization in pregnant women and in newborns. Furthermore, there are few studies analyzing hospital's net income (revenues and costs).
Study design: The cross-sectional study took place in two Bavarian clinics. Available data regarding women and newborns were collected using a standardized questionnaire, personal IDs and medical records in addition to AMR/MSSA screening. Economic data consisted of estimated hospitalization costs, calculated using a billing system called G-DRG (German-Diagnosis Related Groups) as well as real hospitalization costs (e.g. staff, medical and non-medical infrastructure costs).
Results: Data from 635 pregnant women and 566 newborns were included. While AMR colonization has shown no significant association with clinical complications, or net hospital income; primipara status and medical condition during pregnancy did. AMR colonization did not have a significant influence on the health status of pregnant women or of the newborns. Net hospital income for pregnant women was mostly negative in 2014. In 2014 and 2015 the majority of the cases had a net income between ±€ 1000. Newborns with clinical complications differed significantly in Apgar score at 1 min, weight, body length and AMR colonization of the pregnant woman and/or the newborn ($p <= 0.05$).
Conclusion: Results indicate that colonization does not lead to increased costs during hospitalization considering real hospitalization costs as well as G-DRG estimated costs. Both DRG groups had similar MSSA and AMR prevalence and health status. In future studies, a Centralized Cost Accounting as billing method and an improved possibility of AMR coding in G-DRG catalog would be desirable.

Introduction

The increasing prevalence of antimicrobial resistant bacteria (AMR) is of public health relevance not only due to associated infections but also due to rising medical expenses. Methicillin Resistant *Staphylococcus aureus* (MRSA) and extended-spectrum-beta-lactamase-producing Enterobacteriaceae (ESBL-E) represent the most frequent AMR in Germany. The rate of MRSA among *Staphylococcus aureus* isolates from German hospitals amounted in the year 2015 to 16.4% (https://ars.rki.de/). In a further study, the prevalence of ESBL-producing *Escherichia coli* in the general German population was 6.3% [1].

However, data regarding the prevalence of AMR in pregnant women and newborns are limited so far. Due to similar transmission ways, production of virulence factors such as Panton-Valentine leucocidin (PVL) and induced infections,

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methicillin susceptible *Staphylococcus aureus* (MSSA) is often used as surrogate parameter for MRSA. Studies from USA [2–4] showed 1 to 24% nasal and/or vaginal colonization with MSSA in healthy pregnant women, out of which 3 to 50% were MRSA. MSSA plays a role in postpartal mastitis [5] as well as in bacteremia in infants [6]. ESBL-E can be linked to urinary tract infections of pregnant women and their children [7].

In Germany, hospitalization costs are usually reimbursed by the health insurance funds using G-DRGs (German-Diagnosis Related Groups) [8]. The G-DRGs represent an economic, medical patient classification system, in which hospital cases are classified into groups based on their diagnoses and treatments. They form the basis for financing, budgeting and accounting of hospital services. It is crucial to apply the G-DRG classification system with the corresponding valid diagnosis and procedure keys for each individual year. So far, there is a lack of data on the health economic relevance of colonization in pregnant women and in newborns. Furthermore, there are few studies analyzing the real hospitalization costs (revenue and cost) [9–11].

Therefore, the Bavarian Health and Food Safety Authority started this study with the aim to assess the prevalence and clinical relevance of MRSA, ESBL as well as MSSA in healthy pregnant women and newborns in two Bavarian gynecological hospitals. One focus was the relevance of colonization with AMR with regards to medical expenses. Furthermore, the difference between estimated and real hospitalization costs has been calculated.

Materials and methods

The study took place between April 2013 and December 2015 at two German clinics and was approved by the ethics committee of Ludwig Maximilians University, Munich. After being offered detailed information, women signed a standardized informed consent form for participation in the study. Participants under 18 years old or with premature membrane rupture, primary, selected or emergency caesarean section, outpatient birth, multiple pregnancy or cervical incompetence were excluded from the study. Participant withdrawal or transfer to another clinic also resulted in exclusion from the study.

During hospitalization, data were collected via a standardized questionnaire, extraction from personal IDs and medical records. Cardiac and circulatory diseases, kidney and thyroid diseases were used as indicators of the health status of the pregnant women. Similarly, the Apgar score, head circumference, body length and weight, were used as health indicators of the newborns.

Right before giving birth, samples were collected from the pregnant woman's nasal, vaginal, perianal and mammary area. Immediately after birth, samples from the nasal and umbilical area were collected from the newborn. Three days after birth, a second

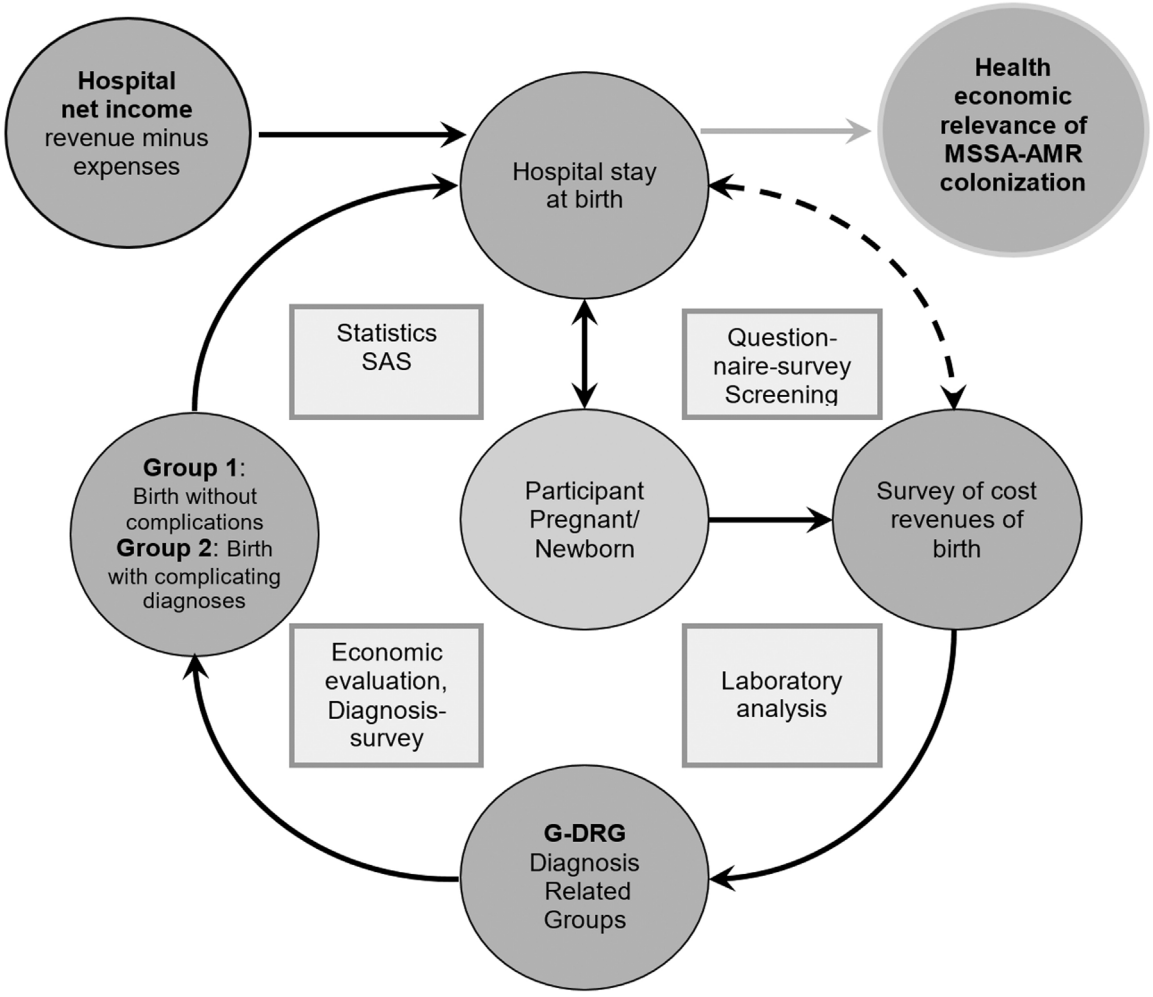

Fig. 1. Cycle of the economic evaluation of relevance of methicillin sensitive *Staphylococcus aureus* (MSSA) and antimicrobial resistant bacteria (AMR). DRG, Diagnosis Related Groups.