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ANTIBIOTIC PROPHYLAXIS PRACTICES IN CAESAREAN SECTION: COMPLIANCE WITH GUIDELINES

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1. INTRODUCTION

Caesarean section (CS) is now one of the most frequently performed operations in the world. Estimates of national rates show a steady rise over recent decades, with wide gaps between regions, and a sizeable share of births in many countries now take place by surgery [1, 2]. Each CS exposes a woman to the risk of endometritis, wound infection and, less often, deeper pelvic sepsis. Those infections prolong stay, delay bonding with the baby and add to antibiotic use. Prevention therefore matters well beyond the operating theatre, and it begins with something simple:

Abstract

This review summarises what the published literature says about antibiotic prophylaxis practice in caesarean section and how closely it follows guidelines, and it reports no new data. It sets out the evidence behind current recommendations on drug choice, timing before skin incision, weight-based dosing and duration, then describes how compliance is audited and which deviations are reported most often. Common barriers include timing habits, uncertainty over penicillin allergy and obesity dosing. Multifaceted interventions, including checklists, pharmacist input and feedback, can improve adherence, although most evidence comes from before-and-after designs. Audit definitions vary so widely that compliance figures are hard to compare, and links between adherence and infection outcomes remain weakly documented.

giving the right antibiotic, at the right time, in the right dose.

The efficacy of prophylaxis is not in doubt. A Cochrane synthesis of trials found that a prophylactic antibiotic reduced endometritis and wound infection markedly compared with none, and the benefit applied to elective as well as emergency operations [3, 4]. Reviews of risk factors identify obesity, labour, ruptured membranes, long operating time and diabetes as the main drivers of infection after surgery, which is why prophylaxis remains important even in women at apparently low risk [5, 6]. What is less settled is how often everyday practice matches the schedule that trials and guidelines describe.

Guidelines on this topic come from obstetric societies, surgical bodies and international agencies, and they largely agree on the essentials [7, 8, 9, 10]. They differ more in detail, for instance on the adjunctive use of azithromycin, on the weight thresholds for doubling the cefazolin dose, and on how to manage patients labelled penicillin-allergic. A reader trying to judge compliance must therefore ask first which guideline was used as the yardstick. This review gathers the published evidence on recommendations, audit methods, reported adherence and ways of improving it, as outlined in table 1 and fig. 1.

The title of this work describes a practice audit, but no hospital records were reviewed for it and no new figures are given. The text draws on published guidelines, trials, systematic reviews and audit reports, and where numbers are mentioned they are those reported by the original authors. The aim is to explain what compliance means, why it is difficult to measure consistently, and what the literature suggests about closing the gap between recommendation and bedside practice. Because the evidence base is international, differences in drug availability, staffing and local policy are noted where they affect interpretation.

International and national guidance does not speak with one voice on every point, and the differences reflect resources as much as evidence. The World Health Organization surgical site infection guidance addresses prophylaxis across surgery and stresses administration before incision, while the Centers for Disease Control and Prevention

(CDC) guideline reaches similar conclusions for general surgery [9, 11]. The English obstetric guideline from the National Institute for Health and Care Excellence (NICE) likewise recommends a single dose of a narrow-spectrum agent before the skin is cut [10]. Where drugs are scarce or only a few agents are stocked, local protocols may legitimately depart from these documents, and audits should state the standard they used.

2. WHAT THE GUIDELINES RECOMMEND

Choice of drug is the least contested element. A first-generation cephalosporin, cefazolin, is recommended in the surgical prophylaxis guidance from the American Society of Health-System Pharmacists (ASHP) and partner societies, and in obstetric guidance, because it covers the skin flora and many of the organisms responsible for endometritis at low cost and low toxicity [7, 8, 10]. International infection-prevention guidance takes the same view of surgical prophylaxis in general [9, 11]. Broader agents are not needed for routine cases and add resistance pressure, which is why stewardship programmes give such emphasis to narrow-spectrum choices [12].

Table 1: Guideline elements for caesarean prophylaxis and the published evidence behind them

Element\issue	Evidence or finding reported	Ref.
Prophylaxis versus none	Antibiotic prophylaxis reduced endometritis and wound infection in randomised trials.	[3, 4]
Agent cefazolin	First-generation cephalosporin recommended for routine prophylaxis in surgery and obstetrics.	[7, 8, 10]
Adjunct azithromycin	Added to cefazolin in labour or ruptured membranes, it lowered a composite of infections.	[13, 14]
Penicillin allergy label	Most labels do not hold up on assessment; labelled patients receive alternatives more often.	[15, 16]
Timing pre-incision	Giving the dose before skin incision lowered infectious morbidity without evident neonatal harm.	[17, 18, 19]

Element\issue	Evidence or finding reported	Ref.
Timing window surgical audit	Best outcomes follow doses given in the hour or so before incision.	[20, 21, 22]
Dose obesity	Tissue concentrations fall with body weight; higher doses are advised in heavier women.	[23, 24, 25, 26]
Duration	A single dose suffices; extension after surgery adds no benefit and drives resistance.	[8, 21]
Audit definitions	Windows and weight bands vary, so compliance figures differ with the standard.	[21, 27]
Stewardship programmes	Audit with feedback, order sets and pharmacist review support adherence.	[12, 28]
Quality improvement	Process redesign and feedback reduced post-caesarean infection in one large programme.	[29]

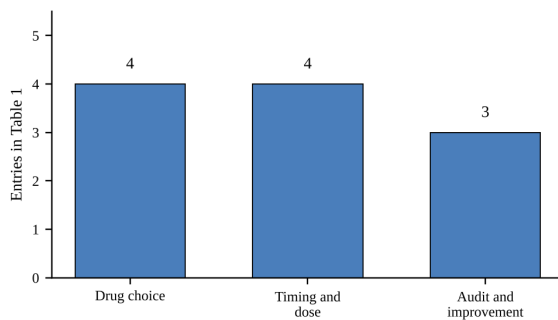


Fig. 1: Number of entries in table 1 by guideline domain

Timing has attracted the most research. For years the antibiotic was delayed until cord clamping. Randomised and meta-analytic evidence showed that giving cefazolin before skin incision lowered the risk of postpartum infectious morbidity without an apparent increase in neonatal sepsis or intensive care admission [17, 18, 19]. Guidance now advises administration within 60 minutes before incision, in line with the older surgical finding that the lowest infection rates followed doses given in the hours just before the cut [20, 21, 22]. Intravenous (IV) administration immediately before the incision is acceptable when the operation is urgent.

Dose is where practice most often parts from guidance. A standard 1 g or 2 g cefazolin dose

was long applied regardless of weight, yet pharmacokinetic studies in obese women found lower adipose tissue concentrations at the time of incision [23, 24]. Guidance from the American College of Obstetricians and Gynecologists (ACOG) later moved to a higher dose for women of high body weight or body mass index (BMI) [26]. The optimal regimen in obesity is still discussed, and trials comparing doses have not settled every question, so audits against a weight-adjusted standard need to say which threshold they used [24, 25].

Repeat dosing is a smaller but real part of the standard. Cefazolin has a short half-life, so surgical guidelines advise giving a second intraoperative dose when the operation lasts beyond roughly two half-lives of the drug, or when blood loss is large, because both reduce tissue concentrations below the level needed to protect the wound [8, 21]. Most caesarean sections are brief and need no second dose, so this element mainly concerns prolonged or complicated cases, including repeat operations with dense adhesions and major haemorrhage, where audit data are scarcer still.

Adjunctive and alternative regimens complete the picture. A large randomised trial in women in labour or with ruptured membranes showed that adding azithromycin to standard cefazolin prophylaxis roughly halved a composite of endometritis, wound infection and other infections [13]. Earlier work on extended-spectrum cover had pointed in the same direction, and a systematic review of emerging concepts gathered that evidence [14, 30]. For women who report a penicillin allergy, guidance favours cefazolin unless the history suggests a severe immediate reaction, with clindamycin plus an aminoglycoside as a common alternative [15, 26]. These nuances mean that complete adherence involves several decisions and not one.

Two aspects of the guidance on duration and adjuncts are often mishandled. The recommendation is a single pre-incision dose, with repeat dosing only for prolonged surgery or major blood loss, and surgical guidance explicitly advises against extending prophylaxis into the postoperative period [8, 21]. Additional skin and vaginal preparation

also form part of infection prevention rather than substitutes for antibiotics. Vaginal cleansing before surgery lowered endometritis in women in labour or with ruptured membranes in some analyses, and national guidance has taken different positions on its use, and the debate over how far prophylaxis should be widened is well summarised elsewhere [10, 31, 32, 33].

3. HOW COMPLIANCE IS MEASURED

Compliance audits compare recorded practice with a written standard. The standard is usually broken into measurable elements: was prophylaxis given, was the agent correct, was the dose appropriate for weight, was the first dose given within the permitted window before incision, and was the course limited to a single dose. A case is called fully compliant only if every element is met, whereas partial compliance counts elements separately. Reports frequently present both views, and the gap between them can be large, because a unit may do well on drug choice and poorly on timing [8, 21, 27].

The data sources deserve scrutiny. Drug charts record what was ordered, anaesthetic records record when it was administered, and the operative note records when the incision was made. A reliable audit links these, but several reports rely on a single source, usually the prescription, and thereby cannot detect timing errors. Electronic records improve completeness yet bring their own pitfalls, since timestamps may reflect documentation rather than administration. Reviewers of surgical audit methods have long pointed to the need for clear definitions of the window and the reference time [21, 22].

Definitions of the timing window explain much of the variation between published studies. Some reports use 60 minutes before incision, others 30 minutes, 120 minutes or simply before the incision. Some count doses given after cord clamping as non-compliant, while others treat them as late but acceptable. A unit that appears to reach a high level of compliance under one definition may look much worse under another. For this reason numerical comparisons across audits, or against a benchmark from a different country, should be made with great caution [20, 21,

27].

Process audits also need to be separated from outcome surveillance. Surveillance of surgical site infection (SSI) after CS follows national or international case definitions, and detection after discharge is incomplete in many settings because women go home within days [6, 11]. A hospital may therefore see good compliance and an unchanged infection rate, or the reverse, without either finding being informative on its own. The literature accordingly treats compliance as a process measure that should be paired with patient-level risk factors and consistent outcome follow-up before conclusions are drawn [5, 6, 11]. Without that pairing, a rise in compliance cannot be credited with any change in infection.

Indicators used in national programmes give a useful template. Typical measures include the proportion of operations in which prophylaxis was given, the proportion in which the dose preceded incision within the accepted window, the proportion receiving the recommended agent, and the proportion in which the postoperative course was limited to the surgical period [8, 11, 21]. Benchmarks are normally set by the programme, and the original surgical studies that tied timing to infection supplied the rationale for the chosen window [22]. Such indicators are practical for routine monitoring, but they say little about dose adequacy unless weight is also recorded.

4. REPORTED COMPLIANCE AND ITS DETERMINANTS

Published audits from different regions describe a mixed picture. Most units give some form of prophylaxis to nearly all women, so failure to prescribe is no longer the main problem. The weaknesses lie in the details: the choice of a broader agent than recommended, doses given after the cord is clamped, fixed doses unrelated to body weight, and courses continued for a day or more after surgery. A large Australian audit across many procedures found that inappropriate prophylaxis was common, with timing and duration among the leading reasons [27]. Obstetric units show similar patterns, although exact figures vary with the audit standard [21, 22].

Habit is the most frequently cited determinant of non-adherence in surgical prophylaxis. Teams that were trained to give the antibiotic after cord clamping continue to do so, and anaesthetists who must interrupt a busy induction to give an additional drug may postpone it. Responsibility is also diffuse. The surgeon, anaesthetist and midwife may each assume another has given the dose, and the drug may be prescribed on one chart and administered from another. Qualitative accounts of surgical prophylaxis emphasise this organisational ambiguity as often as lack of knowledge, and they note that individual clinicians may be entirely familiar with the guideline yet still see no personal responsibility for the dose [21, 29].

Patient factors also play a role. Obesity complicates dose selection because the dose that works for an average woman may give lower tissue concentrations in a larger one [23, 24, 25]. Penicillin allergy labels lead many clinicians to avoid cefazolin, though most of those labels do not withstand formal assessment and the cross-reactivity between penicillin and cefazolin is low because its side chain differs [15, 16]. Labelled patients are more likely to receive alternative drugs and have been reported to have more surgical site infection, so correcting the label is itself a compliance intervention.

System-level conditions matter as well. Availability of the right drug in theatre, whether cefazolin is stocked in premixed form, and whether the guideline is accessible at the point of care all affect practice. Resource-limited settings face additional constraints, including intermittent supplies and lack of pharmacy support [9, 29]. Surveys of stewardship capacity show that many hospitals have no dedicated programme, which leaves compliance to individual vigilance and to chance [12, 28]. Where systems were redesigned, rather than staff simply told to do better, reported gains tended to be larger and last longer.

Beliefs about the neonate deserve separate mention, because they persist after the evidence has moved on. Some clinicians still worry that giving the antibiotic before the cord is clamped might complicate the evaluation of a sick newborn, or encourage

resistant organisms in the infant. Trials and meta-analyses found no excess of neonatal sepsis or intensive care admission with pre-incision dosing, yet the concern is described in surveys of obstetric practice and slows protocol change [17, 18, 19]. Addressing the belief directly, with the data, tends to be more convincing than repeating the recommendation.

Antibiotic exposure has costs beyond the individual patient, and these are an additional reason to care about compliance. Broader agents than needed, repeated doses and courses extended into the postoperative days all increase selection pressure for resistant organisms in the woman, the unit and the community. Stewardship programmes treat unnecessary surgical prophylaxis as a prominent target for this reason, and the WHO guidance also advises against prolonging it [9, 12]. Compliance with the narrow, short regimen is therefore both a patient safety measure and an antimicrobial resistance measure, and hospital managers who see it only as paperwork may underestimate what is at stake.

5. STRATEGIES TO IMPROVE ADHERENCE

The most effective interventions in surgical prophylaxis combine several components. A written protocol is the foundation, but the reports that show improvement usually add an operating-theatre checklist item that asks directly whether the antibiotic has been given, premixed or pre-drawn doses in the theatre, and regular feedback of unit results to the team [8, 9, 29]. A continuous quality improvement programme across Colombian hospitals reported reductions in infections after caesarean section, and the authors attributed gains to process changes and data feedback rather than to any single drug choice [29].

Stewardship frameworks supply the structure that single-unit projects often lack. An international survey and a conceptual review of stewardship describe the elements of institutional programmes in use: prospective audit with feedback, formulary restriction, education, and local guidelines derived from national ones [12, 28]. Pharmacists contribute

at several points. They help set up order sets with weight-based default doses, review penicillin allergy labels, and monitor duration. Electronic order sets are especially useful because they can encode the pre-incision timing and the weight band at the moment of prescribing, and they allow the pharmacy to extract compliance data without manual chart review, which lowers the running cost of audit considerably [12, 29].

Evidence for each component is stronger than evidence for the package, and the individual elements are rarely tested apart. Most improvement studies are before-and-after audits within a single institution, and secular trends, new staff and increased awareness during the audit itself may all inflate apparent gains. Some report sustained improvement over several years, while others show decay once attention moves on. Randomised or stepped-wedge designs are rare. It is therefore reasonable to expect that a multifaceted approach helps, but less reasonable to predict how large the effect will be in a particular hospital [12, 21, 29].

Surgical safety checklists provide one of the more practical hooks. A sign-in or time-out question that asks whether prophylaxis has been given within the last hour places the decision in front of the whole team at the moment when it can still be corrected, and it removes dependence on one person remembering. Infection-prevention guidance recommends embedding prophylaxis into such routines, and the Colombian programme included process changes of this type [9, 11, 29]. The benefit comes from timing the prompt correctly, since a question asked after the incision cannot rescue the pre-incision window. Where checklists have been introduced without a specific antibiotic item, the effect on prophylaxis timing has generally been smaller.

6. LIMITATIONS AND FUTURE DIRECTIONS

Several limitations affect how far the literature can be trusted. Audit standards and definitions differ so much that compliance figures cannot be pooled, and most reports come from single centres with modest numbers. Documentation errors affect timing

data. Few studies adjust for case mix, so that a hospital with more emergency or obese patients may appear less compliant simply because its work is harder [14, 21, 27]. Very few studies connect process adherence to infection outcomes in the same women with enough power to show an effect, so the assumption that better compliance means fewer infections rests mainly on trial evidence rather than on audit data [3, 17, 19].

The next steps are fairly clear. Consensus definitions of compliance, including a standard timing window and weight bands for dosing, would allow audits to be compared. Linking pharmacy, anaesthetic and theatre records electronically would improve data quality and reduce manual effort. Better trials of dosing in obesity and of azithromycin in different settings are needed, along with research on resistance trends after wider adjunctive use [13, 24, 25]. Finally, studies in low-resource units should test low-cost interventions such as checklists and premixed doses, since that is where both the burden of surgery-related infection and the gap in evidence are greatest [2, 9].

7. CONCLUSION

The evidence supports a consistent core for caesarean prophylaxis: a single dose of cefazolin, given before skin incision, adjusted for body weight, with azithromycin added for women in labour or with ruptured membranes and sensible handling of penicillin allergy labels [3, 7, 8, 13, 17, 26]. These recommendations rest on randomised trials and meta-analyses, and obstetric and surgical bodies largely agree on them [9, 10]. The remaining uncertainty concerns the best dosing strategy in obesity and the place of vaginal cleansing, not the broad principle, on which the guidance bodies agree [24, 25, 32, 33].

Practice lags behind the recommendations mainly in timing, dose and duration, and audit evidence shows that habit, unclear responsibility and patient factors all contribute [21, 22, 27]. Multifaceted programmes combining protocols, checklists, order sets, pharmacist review and feedback give the most convincing improvements, although most evidence comes from

uncontrolled before-and-after studies [12, 28, 29]. Common definitions of compliance, paired with consistent outcome surveillance, are the clearest priority for future work, together with trials that test which components of a programme actually matter [6, 11].

8. ABBREVIATIONS

ACOG-American College of Obstetricians and Gynecologists, BMI-Body mass index, CS-Caesarean section, IV-Intravenous, NICE-National Institute for Health and Care Excellence, SSI-Surgical site infection, WHO-World Health Organization, CDC-Centers for Disease Control and Prevention, ASHP-American Society of Health-System Pharmacists

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10. AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

11. CONFLICT OF INTERESTS

Declared none

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