Cost of managing atomic postpartum haemorrhage with uterine balloon tamponade devices in public health settings of Maharashtra, India: an economic microcosting study

Siddesh Sitaram Shetty, Kusum Venkobrao Moray, Himanshu Chaurasia, Beena Nitin Joshi

ABSTRACT

Objective Postpartum haemorrhage (PPH) is the worldwide leading cause of preventable maternal mortality. India offers free treatment for pregnancy and related complications in its public health facilities. Management with uterine balloon tamponade (UBT) is recommended for refractory atomic PPH cases. As part of health technology assessment to determine the most cost-effective UBT device, this study estimated costs of atomic PPH management with condom-UBT, Every Second Matters (ESM) UBT and Bakri balloon UBT in public health system of Maharashtra, India.

Design Health system cost was estimated using primary economic microcosting, data from Health Management Information System and published literature for event probabilities.

Settings Four public health facilities from the state of Maharashtra, India representing primary, secondary and tertiary level care were chosen for primary costing.

Outcome measures Unit, package and annual cost of atomic PPH management with three UBT devices were measured. This included cost of medical treatment, UBT intervention and PPH related surgeries undertaken in public health system of Maharashtra for year 2017–2018.

Results Medical management of atomic PPH cost the health system US$37 (95% CI 29 to 45) per case, increasing to US$44 (95% CI 36 to 53) with condom-UBT and surgical interventions for uncontrolled cases. Similar cost was estimated for ESM-UBT. Bakri-UBT reported a higher cost of US$59 (95% CI 46 to 73) per case. Overall annual cost of managing 27,915 atomic PPH cases with condom-UBT intervention in Maharashtra was US$1,226,610 (95% CI 870,250 to 1,581,596).

Conclusions Atomic PPH management in public health facilities of Maharashtra with condom-UBT, ESM-UBT or Bakri-UBT accounts to 3.8%, 3.8% or 5.2% of the state’s annual spending on reproductive and child health services. These findings can guide policy-makers to include PPH complication management in publicly financed health schemes. Economic evaluation studies can use this evidence to determine cost effectiveness of UBT in Indian settings.

Strengths and limitations of this study

To our knowledge, this is the first study from India comprehensively assessing public health system costs for overall management of atomic postpartum haemorrhage (PPH) with medical interventions, uterine balloon tamponade (UBT) and surgical management across all public healthcare levels in the state.

The study uses clinical effectiveness evidence of individual UBT devices to determine health system costs.

As disaggregated Health Management Information System data in the study setting was not available for PPH, literature-based event probability estimates from the Indian context were relied on to estimate costs.

An assumption was made that for a particular UBT device, all eligible cases would receive only that particular UBT across all facilities.

INTRODUCTION

The global shift towards Universal Health Coverage indicated by Sustainable Development Goals (SDG) needs robust financing mechanisms. To achieve desired targets, evidence informed by costing studies can be vital to support financing decisions. Information on cost enables improved resource allocation, thus strengthening policy measures to attain highest value for a given investment. A key priority under the SDG health goal is reduction of global maternal mortality levels to less than 70 per 100,000 live births by year 2030. Evidence confirms women’s health to be associated with development and economic performance of a country. A marginal health investment at lower Gross Domestic Product (GDP) levels seen commonly in low or lower-mid income countries is found to have higher effects on health outcomes.

Correspondence to
Dr Beena Nitin Joshi; bjoshithane@gmail.com

© Author(s) (or their employer(s)) 2021. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

1Regional Resource Hub for Health Technology Assessment in India, Indian Council of Medical Research—National Institute for Research in Reproductive Health, Mumbai, India

2Department of Operational Research, Indian Council of Medical Research—National Institute for Research in Reproductive Health, Mumbai, India

Check for updates
Improved maternal health not only reduces household healthcare expenditure, but is also associated with long-term economic benefits to the society.

In spite of a low spending of 1% of GDP on public health expenditure, India has managed to reduce maternal mortality ratio down to 122 per 100,000 live births by the year 2015–2017, largely attributed to reforms such as institutionalisation of deliveries, provision of free cashless services to pregnant women and addressing social determinants of health.3–5 Despite ongoing efforts, India still accounts for nearly one-tenth of all maternal deaths globally with haemorrhage as the leading cause.6 Postpartum haemorrhage (PPH) accounts for more than two-thirds of all global maternal deaths due to bleeding.7,8 PPH is defined as maternal blood loss of 500 mL or more within 24 hours after delivery and affects nearly 3%–6% of all women giving birth in India.9 Atony of uterus is the most common PPH type responsible for nearly 80% of all cases.10

Indian guidelines base PPH management on principles of treatment for shock, cause-specific PPH management and patient stabilisation before referral to higher facilities.11 India has initiated standardisation of Labour Rooms under the ‘Dakshata’ initiative thus equipping delivery rooms to provide comprehensive care at all times. In accordance with the WHO guideline for atonic PPH management, uterotonic drugs remain the mainstay of treatment in India.12 Haemodynamic stabilisation and supportive resuscitation measures are expected to be kept ongoing. Use of uterine balloon tamponade (UBT) device is recommended if uterotonic agents fail in controlling atonic PPH bleeding. At primary level in India, all atomic PPH cases are expected to be provided medical management and UBT intervention to stabilise and control bleeding before referral to higher facility for observation or further interventions. Cases uncontrolled after UBT insertion at secondary or tertiary level may require B-Lynch compression suturing, stepwise devascularisation surgery (uterine, or internal iliac artery ligation) or other procedures depending on availability of expertise and health infrastructure. Hysterectomy, a lifesaving procedure may be indicated after failed conservative measures or directly after UBT insertion based on patient response. Obstetric intensive care unit (ICU) admission may be needed for observation or managing complications due to PPH.

UBT intervention for atonic PPH is a relatively simple life-saving technique and can be used even in low resource settings with limited provisions for surgery, blood transfusion or referral mechanisms. UBT technique is clinically effective in controlling PPH bleeding and reduces need for further surgical interventions.13 Timely use of UBT device can potentially be cost saving by improving maternal morbidity and mortality outcomes. Multiple UBT devices specifically designed, assembled or modified for use in PPH management are currently available. Being economical, an assembled condom-UBT device is the recommended standard of care (SOC) for atomic PPH management in India.14 In the state of Maharashtra where this study was undertaken, apart from the recommended condom-UBT device, Bakri balloon and Every Second Matters (ESM)-UBT, two ready to use sterile packed devices made available by non-governmental organisations are used across different public health settings.15–17 The three UBT devices have certain distinct features giving each an advantage over the other. Literature reports varying clinical effectiveness and price for these UBT devices. Table 1 shows distinct characteristics of these three UBT devices used in atomic PPH management, collated from a literature review undertaken separately (online supplemental table 1).

Under India’s flagship Pradhan Mantri Jan Arogya Yojana (PMJAY) public health insurance scheme, a woman is entitled to cashless treatment package cost of US$178 (rupies 11,500) for high-risk vaginal deliveries and all caesarean sections. Evidence suggests that despite improved maternal outcomes with publicly sponsored schemes, extent of out-of-pocket expenditure for institutional delivery remains high especially with pregnancy complications.18 At present, the existing packages do not cover the postpartum PPH complication and there is no documented health system cost available for management of this condition. The Ministry of Health and Family Welfare, Government of India is assessing the most cost-effective UBT device for atomic PPH management in the public health system given the emerging evidence for relatively low cost ESM-UBT alternative.19–21 The policy decision to make a UBT device available for PPH management across health facilities will have associated cost and health outcome implications. This study aimed to calculate public health system cost of atomic PPH management with SOC, that is, condom-UBT recommended by the 2015 Indian guidelines for PPH management with similar projections for ESM-UBT and another globally used Bakri-UBT device.15

METHODS

This costing study was part of a Health Technology Assessment project to evaluate the most cost-effective UBT device for atomic PPH management in India. An economic costing from the health system perspective using primary bottom-up microcosting, data from Health Management Information System (HMIS) and literature review for event probabilities were used to determine and compare unit, package and annual cost of atomic PPH management with condom-UBT, ESM-UBT and Bakri balloon (Bakri-UBT) devices in public health facilities of Maharashtra, India. State health department administrative approvals and consent from respective health facility authorities were obtained before undertaking the study.

Patient and public involvement

There was no patient or public involvement in this study design, conduct or reporting of this study and hence no consent was obtained.
| UBT device              | Cost of device                          | Clinical effectiveness* | Advantages                                                                 |
|------------------------|-----------------------------------------|-------------------------|-----------------------------------------------------------------------------|
| Condom-UBT             | US$2 (rupees 128)† Assembly components  | 92.3%                   | Inexpensive, Assembled using available resources, Modified versions are used to assess blood loss post insertion |
|                        | commercially available                   |                         |                                                                             |
| ESM-UBT                | US$6 (rupees 397)‡ Commercially not    | 95.3%‡                  | Relatively inexpensive, Specifically designed for PPH use, All components needed for assembly available in a sterile pack, US-Food and Drug Administration (FDA) approved device |
|                        | available at present                    |                         |                                                                             |
| Bakri Balloon UBT      | US$148 (rupees 9554),§ Commercially   | 84.3%                   | Ready to use, Specifically designed for PPH use, Comes in a sterile pack, Has drainage outlet to measure ongoing blood loss, US-FDA approved device |
|                        | available at present                    |                         |                                                                             |

*Estimated from literature review of 33 studies.
†Calculated using health facility purchase lists.
‡Strength of evidence is limited, based on evidence available from three case-series studies.
§ESM, Every Second Matters.

**Study settings**

Maternal healthcare in the Indian public system is delivered through a three-tier system. The facilities in this study were classified depending on availability of services for atonic PPH management. Primary-level care for PPH management starts at Primary Health Centers (PHC) that is equipped with skilled birth attendants and a medical officer. Secondary level is made by Community Health Centers and Sub-District Hospitals (SDH) that additionally are equipped with obstetrics-gynaecology (OBGYN) specialist, operation theatre and facilities for blood transfusion. Tertiary level comprises District Hospitals (DH) and medical colleges having additional advanced intervention and ICU facilities. The study enrolled four public health facilities from the state of Maharashtra, India to ensure representation of all three levels of care. A convenience sample of one PHC, SDH, DH, and a tertiary medical college from Mumbai metropolitan region in Maharashtra were chosen for data collection.

**Data collection**

Cost data for 1-year duration from April 2017 to March 2018 were collected by adapting a validated standard tool developed for costing of health services in India. Cost resources were broadly classified into cost centres like human resources, infrastructure, medical equipment, non-medical equipment, drugs, consumables and utilities like electricity, water and laundry. Data on annual quantity or facility consumption for resources were obtained from sources like salary slips, departmental records, facility stock reports, patient record registers, pharmacy records, indent books, bills, statements of the accounts department, building plan of health facilities and civil department records. Source of data for each respective costing centre is reported in table 2. These data were complemented by facility surveys to further collect information on infrastructure and availability of medical and non-medical equipment. Floor area measurements were undertaken to account for area utilisation across different departments of the facility. Staff were interviewed for time allocation to assess time spent on different PPH activities as a proportion of their total working hours. A total of 16 doctors, 26 nursing staff, 5 pharmacists and 11 technical or administrative staff across chosen facilities were interviewed. As an example, all doctors were asked questions pertaining to time spent on each patient for PPH specific activities and other routine tasks like time spent in outpatient department, inpatient department (IPD), surgery, teaching, documentation and administrative services. Time spent by the senior-most doctor in performing an obstetric hysterectomy out of all routine tasks was used in costing obstetric hysterectomy procedure for eligible PPH cases. Time allocation interview findings are presented in online supplemental material 1 (online supplemental table 2).

Data on number of obstetric services like vaginal or caesarean section deliveries, number of obstetric surgeries, hysterectomies, number of blood transfusions, inpatient admissions, emergency or obstetric ICU admissions provided at respective facilities were obtained from available facility records like written registers, patient record registers, electronic health records and HMIS sources. These data were collected as facility records and HMIS indicators specifically for PPH were unavailable. To compute number of PPH services provided...
Table 2  Costing assumptions and apportioning

| Cost centre                         | Source of data                              | Numerator                                      | Denominator                                      |
|-------------------------------------|---------------------------------------------|------------------------------------------------|-------------------------------------------------|
| Human resource cost                 | Salary slips, departmental records, time allocation interview | Proportional cost for time spent on specific component of atonic PPH management | Total working hours                               |
| Area cost                           | Facility survey, civil department records   | Proportional cost for time spent on specific component of atonic PPH management | Total time spent in the given facility area       |
| Drug and consumable cost            | Facility stock reports, indent books, patient record registers, pharmacy records | Proportional cost for number of patients requiring drugs and consumable for a specific component of atonic PPH management | Total number of cases accessing drugs and consumables |
| Medical and non-medical equipment cost | Facility observations, facility stock reports, | Proportional cost for time spent on specific component of atonic PPH management | Total working hours                               |
| Electricity                         | Facility survey, departmental records, electricity bills | Proportional cost for time spent on specific component of atonic PPH management | Total working hours                               |
| Water                               | Departmental records, water bills           | Proportional cost of area required for specific component of atonic PPH management | Total facility area                               |
| Laundry                             | Departmental records, facility registers    | Proportional cost for atonic PPH patients requiring laundry | Total number of indoor patients at the facility   |

PPH, postpartum haemorrhage.

Table 2 provides apportioning of time spent on each activity, number of patients treated, and proportional cost for specific components of atonic PPH management.

Annually at each facility, event probability estimates for atonic PPH incidence in Indian settings, clinical effectiveness of three UBT devices in controlling atonic PPH bleeding (targeted literature review), probability of PPH-related surgeries, its success rate, morbidity and PPH mortality rates were obtained from published literature sources. 9 11 25–27 Facility collected data along with India-specific PPH clinical literature were used to analyse and compute unit, package and annual cost for atonic PPH management components across healthcare levels in Maharashtra, India.

Data analysis

To determine PPH events occurring at facility level, PPH incidence rate in vaginal and caesarean section deliveries were applied to facility reported deliveries to determine number of atonic PPH cases expected annually at the given facility. Proportion of atonic PPH cases uncontrolled after medical management determined number of beneficiaries eligible for UBT insertion at the facility. Clinical effectiveness parameters for each individual UBT device derived from literature review determined requirement of subsequent type and number of surgeries with each individual UBT expected at the healthcare level. Supplemental material provides PPH parameters obtained from literature along with computed number of services specific to facilities used in cost calculation (online supplemental tables 3 and 4).

Monetary value obtained from sources like salary slips, department records for human resources, civil department records for area, facility records for drugs and equipment, and departmental records, facility registers and bills for utilities were respectively attached to collected quantity of each resource utilised across cost centres. For cost analysis, resources were classified into capital and recurrent items. Capital resources were annualised using the India recommended 3% discount rate and factoring in life expectancy and annual maintenance rate of items. 28 Overall cost for services provided at the facility across cost centres was apportioned specific to atonic PPH management component by considering time or proportion calculated for atonic PPH activity being costed, number of total activities under the same category performed at facility and applying standard apportioning methods based on shared or exclusive nature of service utilisation. 29 Human resource salaries were apportioned based on time allocation interviews for a given atonic PPH activity out of total working hours for all services provided. Area was apportioned based on proportional time spent for an atonic PPH activity in the given area out of all activities taking place in the same area. Drugs and consumables were apportioned as a proportion of utilisation for number of cases out of utilisation for all PPH treated patients. Medical and non-medical equipment were first annualised and then apportioned as the proportion of time used specifically for the given PPH activity out of all activities. Utilities like water and electricity were apportioned proportionally to floor area occupied for a particular service. Table 2 provides apportioning methods and corresponding data sources used in cost calculation. Online supplemental material 1 provides an
example of apportioning methods and assumptions used in cost calculation. Worksheets were developed for cost calculation of each component at each facility followed by weighted aggregation of costs to the level of care individually for each UBT type. For example, unit condom-UBT insertion cost at DH and medical college was aggregated to get a unit condom-UBT insertion cost for tertiary level. All costs are presented in US$ and Indian National Rupee currency. A conversion rate of US$1=64.5 rupees for the year 2017–2018 was used. Data were analysed using Microsoft Excel 2016.

Unit costs
Unit costs were calculated for each component of atomic PPH management expected at the respective healthcare level. This included cost of medical management for atomic PPH, UBT insertion for refractory cases, devascularisation surgery, hysterectomy, IPD admission, ICU admission and cost of patient referral at respective levels. Denominators like number of atomic PPH cases, number of UBT eligible beneficiaries, number of referrals, number of consequential conservative or obstetric hysterectomy surgeries determined from collected data sources along with apportioned facility cost across cost centres was used to compute per beneficiary unit cost for the identified component of atomic PPH management. Unit cost of UBT insertion included the cost of UBT device. Unit cost for medical treatment, referral and IPD admission were expected to remain unaffected irrespective of the type of the UBT device used. For these services, costs were calculated only for SOC that is, management with condom-UBT device.

Package costs
To account for treatment combinations used in management of atomic PPH, treatment package costs were determined. For a certain treatment, package cost was calculated by adding unit cost associated with all treatment components for management at respective healthcare level. For all patients at primary and secondary care requiring transport, referral costs were added to get treatment package costs.

Annual costs
Unit and package cost calculation was followed by annual health system cost estimation for an annual cohort of women in Maharashtra experiencing atomic PPH after delivering in public healthcare facilities. Number of deliveries occurring across the three respective public healthcare levels in Maharashtra were combined with respective PPH service utilisation units to get pooled annual cost for a given service. Overall annual health system cost was then estimated by combining annual health system cost of medical management, further course of interventions using UBT device in uncontrolled cases and UBT training cost. Unit cost for every treatment component at each facility was first aggregated to primary, secondary and tertiary level and then applied to the annual eligible population cohort in Maharashtra to estimate annual costs with each UBT device.

Certain methodological assumptions were made during cost analysis. It was assumed that for a particular UBT device, all eligible atomic PPH cases would receive only that particular UBT across facilities. It was assumed that at primary level, all women after medical management or UBT insertion would immediately be referred for secondary care. Unit calculated cost for per day IPD or ICU admission of patients at chosen facilities were apportioned to literature based atomic PPH length of stay to estimate IPD and ICU costs for atomic PPH management.

Cost of blood transfusion and other resuscitation measures were incorporated in unit costs throughout management and are not calculated separately. Training costs were estimated for one day training of healthcare providers. Due to time and resource limitation for primary estimation of PPH referral costs, an inflation adjusted cost of US$15.5 (rupees 1001) per case was used from a published Indian primary economic costing study that calculated public health system cost of transportation for institutional delivery services in three districts of an Indian state. B-Lynch suturing and stepwise devascularisation surgery in this study were considered as a single unit for cost calculation.

Probabilistic sensitivity analysis was used to address joint uncertainty effect of input parameters on costs. A beta distribution for probabilities and proportions, gamma distribution for cost and resource use was assigned to vary parameters on both sides. As drugs and consumables are procured by the government at a negotiated price whereas market prices show variation on the higher side, these were varied by 50% and 100% on lower and upper limits respectively. UBT device price was assumed to vary by 50% on both sides. Remaining parameters such as salaries, rental prices, medical and non-medical equipment, utilities and utilisation of services were varied by 25%. Monte Carlo simulations were run to obtain 1000 unit cost estimates. These estimates were used to determine 95% CI limits for all reported costs.

RESULTS
The chosen sample of four public health facilities from Maharashtra reported 7208 vaginal and 2516 caesarean section deliveries in the year 2017–18. Of the 9724 total deliveries, 293 women were expected to experience atomic PPH. Twenty-nine out 293 cases would remain uncontrolled after medical management, thus becoming eligible for UBT device insertion. Further depending on clinical effectiveness of individual UBT device in controlling bleeding, remaining cases undergo surgical intervention depending on infrastructure and resource availability at respective clinical setting (online supplemental table 3).

Unit costs
Medical treatment of atomic PPH cases costs the health system US$0.7 (rupees 42), US$5 (rupees 322) and US$9.4

Shetty SS, et al. BMJ Open 2021;11:e042389. doi:10.1136/bmjopen-2020-042389
(rupees 609) per patient at primary, secondary and tertiary levels respectively. For uncontrolled cases requiring further intervention, condom-UBT (SOC) insertion costs US$2.5 (rupees 160), US$5.3 (rupees 339) and US$6.5 (rupees 422) at the three respective levels. Devascularisation group of surgeries for uncontrolled cases after condom-UBT insertion costs US$75.4 (rupees 4864) per case at tertiary level. Similarly, hysterectomy procedure costs US$120.6 (rupees 7782) per case at secondary and US$84.8 (rupees 5471) at tertiary level. Table 3 provides the health system unit costs with condom-UBT, ESM-UBT and Bakri-UBT. IPD admission for such treatment combinations can be derived from the given unit cost table. Alternatively, if ESM or Bakri-UBT device is used in controlling atonic PPH, package cost varies for different levels. Table 4 lists treatment package cost estimates for atomic PPH management with three UBT devices.

### Annual costs

Annual cost to the public health system was estimated for managing 27,915 women experiencing atomic PPH annually out of the 969,264 deliveries reported by the state of Maharashtra for the year 2017–2018. The estimated

### Table 3 Unit costs for atomic postpartum haemorrhage (PPH) management components across public health facility levels in Maharashtra, India (US$1=64.5 rupees)

| Per patient unit cost with condom-UBT in US$ | Medical treatment | UBT insertion | Devascularisation | Hysterectomy | Inpatient admission | ICU admission |
|---------------------------------------------|-------------------|--------------|-------------------|--------------|-------------------|--------------|
| **Primary**                                 | 0.7 (0.4 to 0.9)  | 2.5 (1.5 to 3.5) | NA                | NA           | NA                | NA           |
| **Secondary**                               | 5.0 (3.5 to 6.6)  | 5.3 (4.1 to 6.5) | 75.4 (49.4 to 104.4) | 120.6 (77.9 to 168.2) | 27.5 (16.8 to 39.5) | NA           |
| **Tertiary**                                | 9.4 (6.7 to 12.6) | 6.5 (5.3 to 7.9)  | 53.0 (41.9 to 64.4) | 84.8 (66.3 to 104.4) | 28.0 (20.7 to 35.9) | 75.9 (50.3 to 104.6) |
| **Per patient unit cost with ESM-UBT in US$**| 0.7 (0.4 to 0.9)  | 6.7 (3.6 to 9.9)  | NA                | NA           | NA                | NA           |
| **Primary**                                 | 5.0 (3.5 to 6.6)  | 8.8 (5.9 to 11.6) | 56.9 (37.1 to 79.0) | 119.9 (79.3 to 162.7) | 27.5 (16.8 to 39.5) | NA           |
| **Secondary**                               | 9.4 (6.7 to 12.6) | 10.4 (8.5 to 12.5) | 51.7 (40.6 to 63.7) | 86.5 (68.0 to 107.1) | 28.0 (20.7 to 35.9) | 75.9 (50.3 to 104.6) |
| **Per patient unit cost with Bakri-UBT in US$**| 0.7 (0.4 to 0.9)  | 148.6 (74.3 to 219.0) | NA                | NA           | NA                | NA           |
| **Primary**                                 | 5.0 (3.5 to 6.6)  | 151.1 (88.0 to 214.8) | 76.8 (51.2 to 103.9) | 119.7 (80.1 to 165.4) | 27.5 (16.8 to 39.5) | NA           |
| **Secondary**                               | 9.4 (6.7 to 12.6) | 153.1 (113.0 to 191.8) | 53.0 (41.6 to 64.7) | 84.8 (67.2 to 103.7) | 28.0 (20.7 to 35.9) | 75.9 (50.3 to 104.6) |

ICU, intensive care unit; NA, Not Applicable; UBT, uterine balloon tamponade.

### Package cost

Of the eligible cases, condom-UBT successfully controls 92.3% cases after device insertion and ongoing medical and resuscitation measures. This combination treatment costs the health system a total of US$46.2 (rupees 2979), US$37.8 (rupees 2437) and US$44.0 (rupees 2838) at three respective levels. This treatment package comprises costs of medical management, UBT insertion, IPD admission and additional referral cost for primary care patients. Treatment package cost for control with devascularisation surgery after condom-UBT insertion and medical treatment has a total health system cost of US$113.2 (rupees 7301) and US$97.0 (rupees 6256) per patient at secondary and tertiary levels respectively. Similarly, a direct hysterectomy for uncontrolled atomic PPH after condom-UBT insertion costs US$158.4 (rupees 10,218) and US$128.8 (rupees 8308) at secondary and tertiary levels, respectively. Less than 4% of the uncontrolled atomic PPH cases with condom-UBT insertion are expected to require ICU facility for atomic PPH management. Health system package costs for such treatment combinations can be derived from the given unit cost table. Additionally, if ESM or Bakri-UBT device is used in controlling atomic PPH, package cost varies on account of device effectiveness and associated resource use.

### Table 4

- Annual cost to the public health system was estimated for managing 27,915 women experiencing atomic PPH annually out of the 969,264 deliveries reported by the state of Maharashtra for the year 2017–2018. The estimated
annual cost of overall medical management for atonic PPH was US$1 032 647 (rupees 66 605 750) or US$36.9 (rupees 2386) per atonic PPH patient. Additionally, 2791 women were estimated to require UBT intervention followed by devascularisation surgery, hysterectomy or ICU facility for uncontrolled cases. The annual cost of managing these uncontrolled cases in public health facilities of Maharashtra, India is US$193 963 (rupees 12 510 610) with condom-UBT, US$188 090 (rupees 12 131 800) with ESM-UBT and US$620 297 (rupees 40 009 169) with Bakri-UBT when used for medically uncontrolled atonic PPH cases.

This corresponds to a per eligible beneficiary cost of US$69.5 (rupees 4482) for control with condom-UBT and subsequent interventions, US$67.4 (rupees 4346) for ESM-UBT and US$59.2 (rupees 3819) per case with Bakri-UBT if made available for atonic PPH management in Maharashtra, India. Table 5 describes the annual health system cost of atonic PPH management in Maharashtra, India.

### Table 4 Treatment package cost for atonic postpartum haemorrhage (PPH) management across public healthcare levels in Maharashtra, India (US$1=64.5 rupees) (95% CI)

| Cost centre | Condom-UBT | ESM-UBT | Bakri-UBT |
|-------------|------------|---------|-----------|
| Package cost for atonic PPH controlled after UBT insertion in US$ (95% CI) | | | |
| Primary | 46.2 (34.9 to 59.1) | 50.4 (38.5 to 63.8) | 192.3 (153.8 to 230.8) |
| Secondary | 37.8 (28.5 to 48.3) | 41.3 (31.9 to 52.0) | 184.1 (147.0 to 222.4) |
| Tertiary | 43.9 (35.4 to 53.3) | 47.9 (39.6 to 57.0) | 190.5 (149.9 to 233.2) |
| Package cost for atonic PPH controlled with devascularisation surgery after UBT failure in US$ (95% CI) | | | |
| Secondary | 113.2 (103.2 to 123.8) | 98.2 (88.5 to 108.7) | 260.9 (218.6 to 304.2) |
| Tertiary | 96.9 (88.7 to 106.3) | 99.6 (91.4 to 109.3) | 243.5 (202.2 to 286.9) |
| Package cost for atonic PPH controlled with direct hysterectomy after UBT failure in US$ (95% CI) | | | |
| Secondary | 158.4 (149.6 to 168.9) | 161.1 (152.1 to 171.7) | 303.8 (256.0 to 355.6) |
| Tertiary | 128.8 (120.5 to 138.6) | 134.4 (126.2 to 144.0) | 275.3 (231.2 to 319.1) |

ESM, Every Second Matters; UBT, uterine balloon tamponade.

### Table 5 Annual public health system cost of managing atonic postpartum haemorrhage (PPH) using three uterine balloon tamponade (UBT) devices in Maharashtra, India (US$1=64.5 rupees) (95% CI)

| Cost centre | Condom-UBT US$ (95% CI) | ESM-UBT US$ (95% CI) | Bakri-UBT US$ (95% CI) |
|-------------|--------------------------|----------------------|------------------------|
| Annual atonic PPH medical management cost (a) | 1 032 647 (688 893 to 1 375 716) | | |
| Annual UBT training cost (b) | 34 109 (25 817 to 42 579) | | |
| Annual cost for uncontrolled atonic PPH cases managed with UBT device and surgical interventions (c) | 193 963 (152 772 to 232 481) | 188 090 (150 393 to 226 901) | 620 297 (386 981 to 857 415) |
| Total annual cost of atonic PPH management (a+b+c) | 1 226 610 (870 250 to 1 581 596) | 1 220 737 (876 187 to 1 566 385) | 1 652 944 (1 224 827 to 2 061 670) |
| Annual UBT device cost | 5540 (2362 to 8664) | 17 182 (7324 to 26 770) | 413 485 (180 326 to 652 695) |
| Per patient cost of medical management for atonic PPH | 36.9 (29 to 45) | | |
| Per patient cost of managing uncontrolled atonic PPH cases with UBT and surgical interventions | 69.5 (47 to 94) | 67.4 (47 to 88) | 222.2 (145 to 299) |
| Per patient health system cost of atonic PPH management | 43.9 (36 to 53) | 43.7 (35 to 52) | 59.2 (46 to 73) |
DISCUSSION

To our knowledge, this is the first study comprehensively assessing public health system cost associated with atonic PPH management in India. A study conducted in Myanmar at a 25 bedded hospital reported cost of PPH management along with other obstetric complications. Similarly, an Egypt study reported estimates of direct health system costs for different procedures used in PPH management at two DHs. Our study specifically estimates primary health system cost for managing atonic PPH across healthcare levels in the Indian public health system. This study focused on estimating the cost of using different UBT devices given their varying reported clinical effectiveness in controlling atonic PPH bleeding. Additionally, we have undertaken costing for medical management, and surgical intervention subsequent to failed UBT treatment across public healthcare levels in India.

Our analysis reported a total cost of US$43.9 (95% CI 36 to 53) per atomic PPH patient with condom-UBT, US$43.7 (95% CI 35 to 52) with ESM-UBT and US$59.2 (95% CI 46 to 73) with Bakri-UBT use in Maharashtra’s public health system for the year 2017–2018. The study from Myanmar reported an inflation adjusted unit cost of US$28 (±1.61) per case for managing PPH in their hospital study setting. The Egypt study reported an adjusted treatment cost of US$110 per case for PPH but reported use of UBT intervention in 3.9% cases as compared with 9.9% in our study. As primary data were not available, the assumption that all those needing UBT intervention would receive it may be one of the reasons for lower unit costs in our study as UBT intervention would reduce subsequent surgical interventions. Neither of the two studies reported UBT intervention costs specifically.

The unit cost of overall medical management for an atomic PPH case in our study was US$36.9 (rupees 2386). Unit cost of UBT device insertion increased gradually with higher facility levels and was dominated by cost of the UBT device itself. Treatment package costs for UBT insertion at primary level included referral cost and hence reported higher costs as compared to secondary or tertiary level. Unit and package costs for surgical intervention subsequent to UBT failure was found to be higher at secondary level as compared with tertiary level in our study. Tertiary level hysterectomy cost at US$84.8 (rupees 5471) per case in our study is in similar range as reported by another Indian study at an adjusted cost of US$95.7 (rupees 6174) for a DH. Likewise, stepwise devascularisation surgery in the Egypt study reported an adjusted cost of US$62 per case is in the similar range to those reported in our findings. Unit and package surgical costs in our study also varied depending on clinical effectiveness of UBT device affecting consumption of facility resources. Cost of condom-UBT device in Indian public health facilities was US$1.9 (rupees 128), one-third the price of ESM-UBT device. Bakri balloon at a market price of US$148 (rupees 9554) in India costs significantly higher in comparison to the other two devices. Bakri-UBT at a higher price and lower reported clinical effectiveness in controlling atomic PPH, accounted for higher unfavourable unit and package costs in our analysis. ESM-UBT reported a marginally higher clinical effectiveness but had a three-time higher device cost as compared with condom-UBT. The unit health system cost however for both condom and ESM-UBT was similar at US$43.9 (rupees 2834) and US$43.7 (rupees 2820).

Cost of medical management for atomic PPH across healthcare levels in this study constitutes a major component of the annual costs (84.2% for condom-UBT, 84.6% for ESM-UBT and 62.5% for Bakri-UBT). This is expected as majority patients are controlled with uterotonics and supportive measures. Remaining portion of annual costs are accounted by UBT and subsequent interventions for uncontrolled cases (15.8% for condom-UBT, 15.4% for ESM-UBT and 37.5% for Bakri-UBT). Both condom and ESM-UBT have lower unit, package and annual costs as compared with Bakri-UBT. However, strength of clinical effectiveness evidence available for ESM-UBT at the time of this study was limited to a few case series studies reporting survival rates. Cost implication of using ESM-UBT device would vary if higher quality of clinical effectiveness evidence across UBT devices along with procurement cost of equipping all Indian public health facilities with a particular device is made available. Cost of UBT device accounted to 0.5% of the annual health system costs for condom-UBT, 1.4% for ESM-UBT and 25% for Bakri-UBT, respectively.

The state of Maharashtra in the year 2017–2018 spent an estimated US$1 220 737 (rupees 78 737 549) or US$1 652 944 (rupees 106 614 919) respectively. Atomic PPH management with condom-UBT in Maharashtra thus accounted to 3.8% of the annual state spending on reproductive and child health (RCH) activities in the year 2017–2018. ESM-UBT would account to a similar 3.8% whereas Bakri-UBT for atomic PPH management would account to a higher 5.2% of the state’s annual RCH spending.

This study empirically derived costs of atomic PPH management across public healthcare levels for a state in India. The WHO guideline development group has identified use of UBT in PPH as a research priority. Our study provides economic evidence for equipping health systems with the choice of a clinically effective UBT intervention that is affordable and suitable for low resource settings like India. Findings of this study can be used to optimise efficiency by improving financial allocation within the health system. Under the revised Janani Shishu Suraksha Karyakaran scheme in India, pregnant women accessing public health facilities are entitled to free treatment for childbirth and pregnancy complications. Implementation under the PMJAY scheme has revised high risk and caesarean section delivery package costs to US$178.
(rupees 11 500). This package is inclusive of drugs, diagnostics, consultations, procedures, stay and food for patients availing care.45 The results from our study can be used to address package costs for the postpartum PPH complication across different publicly financed health schemes to avoid any financial burden on beneficiaries as reported for institutional deliveries in India.19

Limitations
The study bases its cost findings from one region of Maharashtra by collecting data from sample facilities across healthcare levels. Given the differences within districts across the state, provisioning and utilisation of healthcare services vary on account of socioeconomic, epidemiological and other contextual factors. Although we have undertaken uncertainty analysis to address these factors to an extent, generalisability of the study results across states of India may be difficult. For analysis, it was assumed that all atonic PPH cases requiring UBT intervention will receive it and a uniform UBT device would be available across all facilities. However, in practice, this might differ resulting in deviation of cost estimates from those reported. Facility-level disaggregated HMIS data on PPH and corresponding service utilisation were not available, so we had to rely on literature-based probabilities to derive PPH service utilisation for costing.

CONCLUSION
The study provides health system cost of managing atonic PPH complication in Indian public health settings. Policy-makers can use these findings to include the clinical condition of PPH to treatment benefit packages under publicly financed health schemes and to inform budgetary allocations to equip the Indian health system with a suitable UBT choice. Economic evaluation studies can use this evidence to determine the most cost-effective UBT choice for Indian settings. In addition to equipping facilities and supply lines with the right commodities, programmes must optimise performance of the health-care providers and ensure efficient referral systems are in place to save a woman’s life.

Acknowledgements
The authors acknowledge the support provided by the Department of Health Research (DHR), MOHFW, Government of India. They are grateful to Dr Dinesh Baswal (Deputy Commissionerer Maternal Health, Division, MOHFW, India) for suggesting the topic to HTAln and Dr Smita Mahale (Director, NIRRH-ICMR, Mumbai, India) for her encouragement and support. They acknowledge the technical support provided by HTAln, DHR and the project staff at the institute. They are grateful for the inputs provided by experts Dr Niranjan Maydeo (Professor and Head, Department of Obstetrics and Gynecology, King Edward Memorial Hospital, Mumbai, India), Mr Pandey Bahuguna (Economist, Clinical Research, NIRRH-ICMR, Mumbai, India), Dr Amit Pardey (Professor, Department of Obstetrics and Gynecology, King George’s Medical University, Lucknow, India), Dr Vanita Suri (Professor and Head, Department of Obstetrics and Gynecology, Postgraduate Institute of Medical Education and Research, Chandigarh, India) and Dr Amit Patel (Program Director, Jivodaya Foundation, Texas, United States of America).

Contributors
BJN, SSS and KVM were responsible for conceptualisation and design of the study. KVM and HC undertook data collection. SS and KVM analysed the data. BJN checked the analysis and edited the manuscript. SSS was responsible for the first draft and all authors contributed to further revisions. All authors read and approved the final manuscript.

Funding
This work was supported by HTAln, Department of Health Research, Ministry of Health and Family Welfare, Government of India granthanumber T.11011/02/2017-HR.

Competing interests
None declared.

Patient consent for publication
Not required.

Ethics approval
The study was approved by the NIRRH Ethics Committee for Clinical Studies (Approval number: D/ICEC/Sci-29/2018).

Provenance and peer review
Not commissioned; externally peer reviewed.

Data availability statement
Data are available upon reasonable request. All unpublished data are available upon reasonable request to the corresponding author BJ through email.

Supplemental material
This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access
This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iDs
Siddesh Sitaram Shetty http://orcid.org/0000-0003-0696-1622
Kusum Venkobrao Moray http://orcid.org/0000-0002-9333-5672
Himanshu Chaurasia http://orcid.org/0000-0003-3679-4415
Beena Nitin Joshi http://orcid.org/0000-0003-2187-4922

REFERENCES
1 Onarheim KH, Iversen JH, Bloom DE. Economic benefits of investing in women’s health: a systematic review. PLoS One 2016;11:e0150120–3.
2 Amri A, Gerdtham U. Impact of maternal and child health on economic growth: new evidence based granger causality and DEA analysis. Sweden: Partners Matern Newborn Child Heal (PMNCH), World Heal Organ, 2013: 1–30.
3 Registrar General of India. Special BULLETIN on maternal mortality in India 2015-17 sample registration system office of registrar general, India, 2019. Available: http://www.censusindia.gov.in
4 Singh PK. India has achieved groundbreaking success in reducing maternal mortality. WHO reg. off. south-east Asia, 2016. Available: https://www.who.int/southeastasia/news/detail/10-06-2018-india-has-achieved-groundbreaking-success-in-reducing-maternal-mortality
5 DGHs. National health profile 2018 13 th issue, 2018. Available: www.who.int/classifications
6 The World Bank. Number of maternal deaths | data, 2015. Available: https://data.worldbank.org/indicator/SH.MMR.DTHS?most_recent_value_desc=true
7 Health and family welfare statistics in India 2017. India Ministry of Health and Family Welfare, Government of India, 2017. Available: https://nrhm-mis.nic.in/PubStatistical_Publications/Family%20Welfare%20Statistics%20in%20India/FW%20Statistics%20in%20India%202017.pdf
8 Say L, Chou D, Gemmill A, et al. Global causes of maternal death: a who systematic analysis. The Lancet Global Health 2014;2:e323–33.
9 Rastogi A, Z. Postpartum haemorrhage | National health portal of India. Nati. heal. portal India, 2017. Available: https://www.nhp.gov.in/disease/gynaecology-and-obstetrics/postpartum-haemorrhage
10 Dutta D. Textbook of obstetrics. 46. 8. India: Jaypee Brothers Medical Publishers (P) Ltd, 2015.
11 Guidelines- MH, National Health Mission, 2020. Available: https://nhm.gov.in/index1.php?lang=1&level=3&sublinkid=839&lid=377
12 Dept. of Reproductive Health and Research W. WHO guidance note on prevention and management of postpartum haemorrhage. 2012. Available: www.who.int/maternal_child_adolescent

13 Ramirez S, Conde-Agudelo A, Borovac-Pinheiro A, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage: a systematic review and meta-analysis. Am J Obstet Gynecol 2020;222:293.e1–293.e52.

14 Division MH, Welfare F. Guidance note on prevention and management of postpartum haemorrhage. India Ministry of Health and Family Welfare, Government of India; 2015: 1–28. https://www.nhm.gov.in/images/pdf/programmes/materna-health/guidelines/Guidance_Note_on_Prevention_&_Management_of_Postpartum_Haemorrhage.pdf

15 Maternal Health – Jiv Daya Foundation. India maternal health Initiative, 2020. Available: https://www.jivdayafound.org/maternal-health

16 MGIMS. Govt of India, NHSRC and Harvard discuss PPH management. 2020. Available: https://www/mgims.ac.in/index.php/component/easyblog/392-govt-of-india-discusses-the-management-of-pph-at-mgims?Itemid=1

17 The Hitavada. ‘Harvard’ helps State’s 11 medical colleges to reduce maternal deaths due to PPH - The Hitavada, 2020. Available: https://www.thehitavada.com/Encyc/2020/3/11-Harvard-helps-State-s-11-medical-colleges-to-reduce-maternal-deaths-due-to-PPH.html

18 Mishra S, Mohanty SK. Out-Of-Pocket expenditure and distress financing on institutional delivery in India. Int J Equity Health 2019;18:99.

19 Ramanathan A, Eckard AL, Durani U, Bartley A, et al. The impact of postpartum hemorrhage on hospital length of stay and inpatient mortality: a National Inpatient Sample-based analysis. Am J Obstet Gynecol 2017;217:344.e1–344.e6.

20 Kumar P, Dhillon P. Length of stay after childbirth in India: a comparative study of public and private health institutions. BMC Pregnancy Childbirth 2020;20:181.

21 Ministry of Health and Family Welfare (Government of India). National health profile (NHPI- India- 2018: central Bureau of health intelligence, 2018. Available: https://www.cbhidghs.nic.in/index1.php?lang=1&level=2&sublinkid=888&lid=1138

22 Prinja S, Manchanda N, Aggarwal AK, et al. Cost & efficiency evaluation of a publicly financed & publicly delivered referral transport service model in three districts of Haryana State, India. Indian J Med Res 2013;138:1003–11.

23 Chauhan AS, Prinja S, Ghoshal S, et al. Cost of treatment for head and neck cancer in India. PLoS One 2013;8:e19132–13.

24 State fact sheet: FY 2018-2019 (April-March) Maharashtra key indicators, 2019. Health management information systemMinistry of Health and Family Welfare, Government of India. Available: https://nhm-mis.nic.in/hmisreports/fmstandard_reports.aspx

25 Streve ATW, Riewpaiboon A, Chakhledkaew U, et al. Treatment cost and costing model of obstetric complications at a hospital in Myanmar. PLoS One 2019;14:e0213141.

26 Vlassoff M, Abdalla HA, Gor V. The cost to the health system of postpartum hemorrhage in Egypt key points, 2016. Available: www.guttmacher.org/publications/download_linked_document?document_id=8549

27 CPI inflation calculator. U.S. Bureau of labor statistics, 2016. Available: https://data.bls.gov/cgi-bin/cpicalc.pl?cost1=27.04&year1=201506&year2=201706

28 Chatterjee S, Laxminarayan R. Costs of surgical procedures in Indian hospitals. BMJ Open 2013;3. doi:10.1136/bmjopen-2013-002844. [Epub ahead of print: 20 Jun 2013].

29 Nampoothiri NJ. NHM in Maharashtra: budget trends 2015-16 to 2018-19. India: National Centre for Advocacy Studies, 2018. Available: http://ncasindia.org/wp-content/pdf/pub/pb/NHM_Publication.pdf

30 National Health Mission, Ministry of Health and Family Welfare, Government of India. National urban health mission: National health mission; 12, 2020. Available: https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=842&lid=308

31 NavjaatShishu Suraksha Karyakram (NSSK). National health mission, 2020. Available: https://nhm.gov.in/index1.php?lang=1&level=3&sublinkid=842&lid=308

32 Ayushman Bharat, National Health Authority. Documents, 2020. Available: https://www.pmjay.gov.in/resources/documents

33 Massachusetts General Hospital. Every second matters for Mothers and babies - Uterine balloon tamponade for postpartum hemorrhage. Massachusetts Gen. Hosp. Emerg. Med, 2018. Available: https://www.massgeneral.org/emergency-medicine/global-health/initiatives-and-programs/every-second-matters-for-mothers-and-babies-uterine-balloon-tamponade-for-postpartum-hemorrhage

34 Burke TF, Ahn R, Nelson BD, et al. A postpartum haemorrhage package with condom uterine balloon tamponade: a prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. BJOG 2016;123:1532–40.

35 Bakri Balloon. Packaging type: box, RS 9500 /pack Gyno car

36 Department of Health Research. Health technology assessment in India a manual, 2018. Available: https://dhr.gov.in/

37 Fox-Rushby J, Cairns J. Economic evaluation - Fox-Rushby, Julia, Cairns, John. Google books, 2005. Available: https://books.google.co.in/books?hl=en&lr=&id=tczsAAAAQBAJ&pg=PP1&ots=nlULueEFMB&sig=qnqRBj0MdwXuHK1ZlITx91FE&redir_esc=y#v=onepage&q&f=false

38 Venugopal P, Indicators WD. The world bank. Manag Labour Stud 1997;1999:135–6.

39 Marshall AL, Durani U, Bartley A, et al. The impact of postpartum hemorrhage on hospital length of stay and inpatient mortality: a National Inpatient Sample-based analysis. Am J Obstet Gynecol 2017;217:344.e1–344.e6.

40 Joseph CM, Bhatia G, Abraham V, et al. Obstetric admissions to tertiary level intensive care unit - Prevalence, clinical characteristics and outcomes. Indian J Anaesth 2018;62:940–4.

41 Ministry of Health and Urban Welfare (Government of India). National health profile (NHPI- India- 2018: central Bureau of health intelligence, 2018. Available: https://www.cbhidghs.nic.in/index1.php?lang=1&level=2&sublinkid=888&lid=1138
### Supplemental material

Table 1.1: Details of the studies included in targeted literature review for the three UBT devices

| Authors         | Study design | PPH success rate | Atonic PPH success rate | Reference |
|-----------------|--------------|------------------|-------------------------|-----------|
| **Condom-UBT**  |              |                  |                         |           |
| Darwish et al.  | RCT          | 28/33 (84.8)     | 28/33 (84.8)            | [1]       |
| Tindell et al.  | Systematic Review | 186/193 (96.4)   | NR                      | [2]       |
| Santhanam et al.| Prospective  | 59/61 (96.7)     | 59/61 (96.7)            | [3]       |
| Rathore et al.  | Prospective  | 17/18 (94.4)     | NR                      | [4]       |
| Aderoba et al.  | Prospective  | 203/229 (88.6)   | 193/214 (90.2)          | [5]       |
| Mishra et al.   | Prospective  | 59/60 (98.3)     | NR                      | [6]       |
| Kandeel et al.  | Prospective  | 48/50 (96.0)     | 28/28 (100)             | [7]       |
| Anger et al.    | RCT          | 56/64 (87.5)     | NR                      | [8]       |
| Dumont et al.   | RCT          | 48/57 (84.2)     | NR                      | [9]       |
| Lohano et al.   | Prospective  | 126/139 (90.6)   | 126/139 (90.6)          | [10]      |
| Hasabe et al.   | Prospective  | 34/36 (94.4)     | NR                      | [11]      |
| Yadav et al.    | Prospective  | 117/122 (95.9)   | 117/122 (95.9)          | [12]      |
| **Bakri-UBT**   |              |                  |                         |           |
| Darwish et al.  | RCT          | 30/33 (90.9)     | 30/33 (90.9)            | [1]       |
| Revert et al.   | Prospective  | 188/226 (83.2)   | 155/183 (84.7)          | [13]      |
| Brown et al.    | Prospective  | 55/58 (94.8)     | 52/55 (94.5)            | [14]      |
| Vintejoux et al.| Retrospective| 25/36 (69.4)     | 25/36 (69.4)            | [15]      |
| Guo et al.      | Retrospective| 288/305 (94.4)   | 131/142 (92.3)          | [16]      |
| Mathur et al.   | Retrospective| 40/49 (81.6)     | 14/17 (82.4)            | [17]      |
| Wang et al.     | Prospective  | 373/407 (91.6)   | 373/407 (91.6)          | [18]      |
| Alkis et al.    | Retrospective| 43/47 (91.5)     | NR                      | [19]      |
| Kaya et al.     | Prospective  | 34/45 (75.6)     | 27/34 (79.4)            | [20]      |
| Laas et al.     | Before and after | 37/43 (86)     | 37/43 (86)              | [21]      |
| Olsen et al.    | Retrospective| 25/37 (67.6)     | 17/24 (70.8)            | [22]      |
| Kong et al.     | Retrospective| 59/81 (72.8)     | 37/59 (62.7)            | [23]      |
| Study            | Design           | Survival Rate | Follow-up Rate | Reference |
|------------------|------------------|---------------|----------------|-----------|
| Cetin et al.     | Retrospective    | 29/39 (74.4)  | 29/39 (74.4)   | [24]      |
| Gauchotte et al. | Before and after | 35/38 (92.1)  | NR             | [25]      |
| Grange et al.    | Retrospective    | 80/108 (74.1) | 26/39 (66.7)   | [26]      |
| Kadioglu et al.  | Retrospective    | 42/50 (84)    | NR             | [27]      |
| Martin et al.    | Retrospective    | 32/49 (65.3)  | 28/42 (66.7)   | [28]      |
| Ogoyama et al.   | Retrospective    | 66/71 (93)    | 31/32 (96.9)   | [29]      |
| Son et al.       | Retrospective    | 239/306 (78.1)| 190/241 (78.8) | [30]      |
| **ESM-UBT**      |                  |               |                |           |
| Ramanathan et al.| Prospective/Retrospective case series | 189/201 (94) * | NR             | [31]      |
| Burke et al.     | Prospective case series | 190/201 (94.5) * | NR             | [32]      |
| Burke et al.     | Prospective case series | 298/306 (97.4) * | 298/306 (97.4) | [33]      |

* - Reported survival rates
NR – Not reported
Table 1.2: Staff time allocation parameters used in costing analysis

| Parameter                                                                 | Value in cost analysis* | Source                                      |
|--------------------------------------------------------------------------|--------------------------|---------------------------------------------|
| Average time taken for UBT device insertion                               | 10 minutes               |                                             |
| Average time taken for normal vaginal delivery in labour room             | 7.25 hours               |                                             |
| Average time taken for vaginal delivery with PPH complication, controlled after medical management in LR | 10.25 hours               |                                             |
| Average time taken for UBT device retention among those controlled with UBT | 24 hours                 |                                             |
| Average time in operation theatre for a caesarean section without complications | 45 minutes               | Reported by senior most doctor              |
| Average time in operation theatre for a caesarean section with PPH complication controlled with medical management | 60 minutes               |                                             |
| Average time in operation theatre for a caesarean section with PPH complication requiring UBT insertion | 75 minutes               |                                             |
| Average time for devascularization surgery after PPH                      | 75 minutes               |                                             |
| Average time for hysterectomy after PPH                                   | 120 minutes              |                                             |
| Average time spent in out-patient department                              | 12 hours/week            |                                             |
| Average time spent in indoor patient management                           | 12 hours/week            |                                             |
| Average time spent in operation theatre                                  | 12 hours/week            |                                             |
| Average time spent in labour room                                         | 2 hours/week             |                                             |
| Average time spent in administration and documentation                    | 10 hours/week            |                                             |
| Average time spent in teaching and training                               | 5.15 hours/week          |                                             |
| Average time spent in out-patient department                              | 12 hours/week            | Reported by sister-in-charge                |
| Average time spent in indoor patient management                           | 12 hours/week            |                                             |
| Average time spent in operation theatre                                  | 6 hours/week             |                                             |
| Average time spent in administrative work                                 | 15 hours/week            |                                             |
| Average time spent in labour room by Grade 4 worker                       | 12 hours/week            | Reported by grade 4 worker                  |
| Average time spent in operation theatre by Grade 4 worker                 | 12 hours/week            |                                             |
| Mean length of stay for OBGYN patients in ICU                            | 3.47 days                | [34]                                        |
| Mean length of ICU stay for PPH patients                                 | 1.5 days                 | [5]                                         |
Table 1.3: Literature based event probabilities used for PPH utilization calculation of healthcare facilities

| Input                                                                 | Value  | Reference |
|-----------------------------------------------------------------------|--------|-----------|
| PPH incidence in vaginal delivery                                     | 3 percent | [35,36] |
| PPH incidence in caesarean delivery                                   | 6 percent | [35,36] |
| Atonic PPH incidence                                                  | 80 percent | [37] |
| Atonic PPH controlled with medical management                         | 90 percent | [38] |
| Clinical effectiveness of condom-UBT device in controlling atonic PPH  | 92.3 percent | Calculated from literature review of 33 studies reported in Table 1.1 |
| Clinical effectiveness of ESM-UBT device in controlling atonic PPH     | 95.3 percent* | Calculated from literature review of 33 studies reported in Table 1.1 |
| Clinical effectiveness of condom-UBT device in controlling atonic PPH  | 84.3 percent | Calculated from literature review of 33 studies reported in Table 1.1 |
| Probability of stepwise devascularization procedure for uncontrolled atonic PPH cases after UBT insertion | 0.85 | [38] |
| Probability of obstetric hysterectomy for uncontrolled atonic PPH cases after UBT insertion | 0.15 | [38] |
| Probability of delivery at primary care level                         | 0.19 | [39] |
| Probability of delivery at secondary care level                       | 0.33 | [39] |
| Probability of delivery at tertiary care level                        | 0.48 | [39] |

* - Estimated from limited evidence from 3 case-series studies reported in Table 1.1

PPH incidence rate in vaginal/caesarean section delivery was applied to reported number of deliveries at each health facility (Table 1.4) to estimate number of PPH and thus proportional atonic PPH cases at the facility. Proportion of these atonic PPH cases uncontrolled after medical and supportive management were eligible for UBT device insertion. Literature review based clinical effectiveness of individual UBT device determined number of patients consequently needing conservative (devascularization) or obstetric hysterectomy surgical intervention at each facility. Table 1.4 shows results of these calculations for each chosen facility.
Table 1.4: Utilization of services for atonic PPH at chosen health facilities of Maharashtra based on primary collected data and event probabilities from literature

| Type of Health facility | Mode of Delivery | Annual number of deliveries | Atonic PPH cases | Atonic PPH controlled with medical management | Cases requiring UBT insertion | Controlled with UBT insertion | Cases requiring further intervention |
|------------------------|------------------|-----------------------------|------------------|---------------------------------------------|-------------------------------|----------------------------------|-------------------------------------|
| PHC                    | Vaginal          | 494                         | 11.86            | 10.67                                       | 1.18                          | 1.09                             | 0.09                                |
|                        |                  |                             |                  |                                             |                               | 1.00                             | 0.19                                |
|                        |                  |                             |                  |                                             |                               | 1.13                             | 0.06                                |
| SDH                    | Vaginal          | 1526                        | 36.62            | 32.96                                       | 3.66                          | 3.41                             | 0.26                                |
|                        |                  |                             |                  |                                             |                               | 3.09                             | 0.57                                |
|                        |                  |                             |                  |                                             |                               | 3.49                             | 0.17                                |
|                        | Cesarean         | 330                         | 15.84            | 14.26                                       | 1.58                          | 1.47                             | 0.11                                |
|                        |                  |                             |                  |                                             |                               | 1.34                             | 0.25                                |
|                        |                  |                             |                  |                                             |                               | 1.51                             | 0.07                                |
| DH                     | Vaginal          | 2986                        | 71.66            | 64.49                                       | 7.17                          | 6.66                             | 0.50                                |
|                        |                  |                             |                  |                                             |                               | 6.04                             | 1.13                                |
|                        |                  |                             |                  |                                             |                               | 6.83                             | 0.34                                |
|                        | Cesarean         | 1045                        | 50.16            | 45.14                                       | 5.02                          | 4.66                             | 0.35                                |
|                        |                  |                             |                  |                                             |                               | 4.23                             | 0.79                                |
|                        |                  |                             |                  |                                             |                               | 4.78                             | 0.24                                |
| Medical college        | Vaginal          | 2202                        | 52.84            | 47.56                                       | 5.28                          | 4.87                             | 0.37                                |
|                        |                  |                             |                  |                                             |                               | 4.44                             | 0.83                                |
|                        |                  |                             |                  |                                             |                               | 5.03                             | 0.25                                |
|                        | Cesarean         | 1141                        | 54.76            | 49.29                                       | 5.47                          | 5.05                             | 0.42                                |
|                        |                  |                             |                  |                                             |                               | 4.61                             | 0.85                                |
|                        |                  |                             |                  |                                             |                               | 5.21                             | 0.25                                |
Methodology for apportioning of unit cost estimation

Example: Unit cost for condom-UBT insertion in labour room of the district hospital

Unit cost for condom-UBT device insertion in labour room (vaginal delivery) of the district hospital was USD 2.84 (INR 182.9). This cost along with unit cost of condom-UBT insertion in operation theatre after cesarean section delivery in district hospital was weighted to get unit cost of condom-UBT insertion at district hospital. The average of weighted insertion cost at district hospital along with similar estimated unit cost for medical college was combined to report the average condom-UBT insertion cost at tertiary level (USD 6.5 (INR 422).

Annual consumption and price data for cost resource heads were obtained from respective sources as stated in Table 2 of the manuscript. Atonic PPH specific clinical data on number of services utilized at respective facilities as stated in Table 1.4 for specific PPH management components were apportioned to that of the total quantity of that particular service category provided at the facility by using time allocation parameters and following reported apportioning methods for each resource head to arrive at unit cost of a particular atonic PPH service delivery at the facility.

The following example describes methodology, apportioning factors and quantity of resources used in calculating unit cost for condom-UBT insertion in labour room (vaginal delivery) of the district hospital (DH). A similar methodology was used for calculation of each respective unit cost reported in the study.

1. Human resources (HR) - For total annual vaginal deliveries (2986) reported at DH, proportional time for annual condom-UBT insertions was obtained as a proportion of total time spent for all condom-UBT insertions (1.19 hours: 10 minutes for single UBT insertion, 7 UBT insertions) to that of total time for vaginal deliveries (21996 hours for 2986 vaginal deliveries) occurring at the facility (Factor 1: 0.00054). This time allocation factor was used to calculate proportional time spent by workforce in all condom-UBT insertions to that of their respective total annual working hours (for 19 working staff of labour room including overhead workers) (Factor 2: 0.0000023). For the working staff, the total annual working hours included time spent across OPD, IPD, Labour room administration, training, teaching, etc. obtained from time allocation interviews (2463 to 2934 total working hours annually). Proportion of labour room time for condom-UBT insertion to total annual working hours (in this case labour room) gave Factor 2.

2. Area - The area cost for labour room was calculated by first factoring the proportion of area used for condom-UBT insertion (labour room area-220 square feet, pharmacy-1800, blood bank-2660) to that of the total hospital area (1246881 square feet) (Factor 1: 0.0038). Factor 2 was time allocation proportion of annual condom-UBT insertion time to that of the total time for all patients in the labour room (Factor 2: 0.000054). Unit space cost for condom-UBT insertion in labour room of DH was obtained by dividing annual area cost by number of condom-UBT insertions at DH.

3. Drug cost – Available drugs and their corresponding annually utilized quantities were used to calculate total annual cost of drugs in labour room of the DH. This was then multiplied with proportion of UBT insertion eligible cases in the labour room (Factor 1: 0.00222) to get annualized and thus unit cost of drugs used along with condom-UBT insertion in labour room of the DH.

4. Medical and non-medical equipment – Using the expected life time of the equipment (10/15 years), a discount rate of 3 percent and an annual maintenance rate of 0.01, annualized costs were calculated. Proportional equipment time spent on condom-UBT insertion to the total time for use of equipment in labour room (Factor 1: 0.00054) gave annual cost of medical and non-medical equipment. This was then divided by eligible UBT beneficiaries to calculate unit cost of equipment for condom-UBT insertion in labour room of the DH.
5. Electricity – As electricity was shared and accounted across the facility, it was first apportioned by proportional area for the labour room out of total facility area multiplied by 2 for electricity to get the first factor (Factor 1: 0.00751). The second factor for apportioning was based on proportional time spent for condom-UBT insertion in labour room (Factor 2: 0.00054).

6. Water – Water as a shared resource was first apportioned by proportional area for labour room out of the total facility area to get the first factor (Factor 1: 0.00751). The second apportioning factor was proportional time spent for condom-UBT insertion in labour room (Factor 2: 0.00054).

7. Laundry – Laundry was apportioned as proportion of eligible cases for condom-UBT insertion to the total indoor patients at the DH (22036). (Factor 1: 0.000256).

Similarly, for surgeries, the district hospital data reported a total of 1169 obstetric surgeries annually. This included 1045 cesarean sections, 39 major surgeries (non-specified) and 85 cases of female sterilization. We derived the number of expected atonic PPH specific surgeries from the given 1045 cesarean sections by applying literature probability estimates as reported in Table 1.1 and 1.2. Time allocation parameters for each type of surgery was then applied to get proportional time factors that was applied to relevant cost centres along with apportioning methods as stated to arrive at unit surgical costs.
REFERENCES

1. Darwish AM, Abdallah MM, Shaaban OM, et al. Bakri balloon versus condom-loaded Foley’s catheter for treatment of atonic postpartum hemorrhage secondary to vaginal delivery: a randomized controlled trial. *J Matern Neonatal Med* 2018;31:747–53. doi:10.1080/14767058.2017.1297407

2. Tindell K, Garfinkel R, Abu-Haydar E, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage in resource-poor settings: A systematic review. *BJOG An Int. J. Obstet. Gynaecol.* 2013;120:5–14. doi:10.1111/j.1471-0528.2012.03454.x

3. Rathore AM, Gupta S, Manaktala U, et al. Condom tamponade in the management of atonic postpartum hemorrhage. *Int J Reprod Contraception, Obstet Gynecol* 2018;7:2276. doi:10.18203/2320-1770.ijrcog20182335

4. Santhanam R, Viswanathan RM, V. P. Condom tamponade in the management of atonic postpartum hemorrhage. *Int J Reprod Contraception, Obstet Gynecol* 2018;7:135. doi:10.18203/2320-1770.ijrcog20182335

5. Kandeel M, Sanad Z, Ellakwa H, et al. Use of Bakri balloon tamponade (BBT) for conservative management of postpartum hemorhage in resource-poor settings: A systematic review. *BJOG An Int. J. Obstet Gynaecol Res* 2012;38:1162–7. doi:10.1111/j.1447-0756.2011.01843.x

6. Anger HA, Dabash R, Durocher J, et al. Efficacy and Feasibility of Chhattisgarh Balloon and Conventional Condom Balloon Tamponade: A 2-Year Prospective Study. *J Obstet Gynecol India* 2019;69:133–41. doi:10.1007/s13224-018-1185-6

7. Mekhael M, Sanad Z, Ellakwa H, et al. Management of postpartum hemorrhage with intrauterine balloon tamponade using a condom catheter in an Egyptian setting. *Int J Obstet Gynecol Obstet* 2016;135:272–5. doi:10.1016/j.ijigo.2016.06.018

8. Anger HA, Dabash R, Durocher J, et al. The effectiveness and safety of introducing condom-catheter uterine balloon tamponade for postpartum haemorrhage at secondary level hospitals in Uganda, Egypt and Senegal: a stepped wedge, cluster-randomised trial. *BJOG An Int J Obstet Gynaecol* 2019;126:1612–21. doi:10.1111/1471-0528.15903

9. Dumont A, Bodin C, Hounkpatin B, et al. Uterine balloon tamponade as an adjunct to misoprostol for the treatment of uncontrolled postpartum haemorrhage: A randomised controlled trial in Benin and Mali. *BMJ Open* 2017;7:1–9. doi:10.1136/bmjopen-2017-016590

10. Lohano R, Haq G, Kazi S, et al. Intrauterine balloon tamponade for the control of postpartum hemorrhage. *J Pak Med Assoc* 2016;66:22–6.

11. Dasabe R, Gupta K, Rathode P. Use of Condom Tamponade to Manage Massive Obstetric Hemorrhage at a Tertiary Center in Rajasthan. *J Obstet Gynecol India* 2016;66:88–93. doi:10.1007/s13224-015-0790-x

12. Yadav S, Malhotra A. A prospective randomized comparative study of Misoprostol and balloon tamponade using condom catheter to prevent postpartum hemorrhage at M. Y. H., Indore, India in vaginal delivered patients. *Int J Reprod Contraception, Obstet Gynecol* 2019;8:591. doi:10.18203/2320-1770.ijrcog20190290

13. Revert M, Cottenet J, Raynal P, et al. Intrauterine balloon tamponade for management of severe postpartum haemorrhage in a perinatal network: a prospective cohort study. *BJOG An Int J Obstet Gynaecol* 2017;124:1255–62. doi:10.1111/1471-0528.14382

14. Brown H, Okeyo S, Manotang H, et al. The Bakri tamponade balloon as an adjunct treatment for refractory postpartum hemorrhage. *Int J Gynecol Obstet* 2016;135:276–80. doi:10.1016/j.jiogo.2016.06.021

15. Vintejoux E, Ulrich D, Mousty E, et al. Success factors for Bakri™ balloon usage secondary to uterine atony: A retrospective, multicentre study. *Aust NZ J Obstet Gynaecol* 2015;55:572–7. doi:10.1111/ajo.12376

16. Guo Y, Hua R, Bian S, et al. Intrauterine Bakri Balloon and Vaginal Tamponade Combined with Abdominal Compression for the Management of Postpartum Hemorrhage. *J Obstet Gynaecol Canada* 2018;40:561–5. doi:10.1016/j.jogc.2017.08.035

17. Mathur M, Ng QJ, Tagore S. Use of Bakri balloon tamponade (BBT) for conservative management of postpartum haemorrhage: a tertiary referral centre case series. *J Obstet
Gynaecol (Lahore) 2018;38:66–70. doi:10.1080/01443615.2017.1328671
18 Wang D, Xu S, Qiu X, et al. Early usage of Bakri postpartum balloon in the management of postpartum hemorrhage: A large prospective, observational multicenter clinical study in South China. J Perinat Med 2018;46:649–56. doi:10.1515/jpm-2017-0249
19 Alkış I, Karahan E, Han A, et al. The fertility sparing management of postpartum hemorrhage: A series of 47 cases of Bakri balloon tamponade. Taiwan J Obstet Gynecol 2015;54:232–5. doi:10.1016/j.tjog.2014.03.009
20 Kaya B, Tuten A, Daglar K, et al. Balloon tamponade for the management of postpartum uterine hemorrhage. J Perinat Med 2014;42:745–53. doi:10.1515/jpm-2013-0336
21 Laas E, Bui C, Popowski T, et al. Trends in the rate of invasive procedures after the addition of the intrauterine tamponade test to a protocol for management of severe postpartum hemorrhage. Am J Obstet Gynecol 2012;207:281.e1-281.e7. doi:10.1016/j.ajog.2012.08.028
22 Olsen R, Reisner DP, Benedetti TJ, et al. Bakri balloon effectiveness for postpartum hemorrhage: A ‘real world experience’. J Matern Neonatal Med 2013;26:1720–3. doi:10.3109/14767058.2013.796354
23 Kong CW, To WW. Prognostic factors for the use of intrauterine balloon tamponade in the management of severe postpartum hemorrhage. Int J Gynaecol Obstet 2018;142:48–53. doi:10.1002/ijo.12498
24 Çetin BA, Aydogan Mathybk, Atis Aydin A, et al. Comparing success rates of the Hayman compression suture and the Bakri balloon tamponade. J Matern Neonatal Med 2019;32:3034–8. doi:10.1080/14767058.2018.1455184
25 Gauchotte E, De La Torre M, Perdriolle-Galet E, et al. Impact of uterine balloon tamponade on the use of invasive procedures in severe postpartum hemorrhage. Acta Obstet Gynecol Scand 2017;96:877–82. doi:10.1111/aogs.13130
26 Grange J, Chatellier M, Chevé MT, et al. Predictors of failed intrauterine balloon tamponade for persistent postpartum hemorrhage after vaginal delivery. PLoS One 2018;13:1–11. doi:10.1371/journal.pone.0206663
27 Kadioglu BG, Tanriverdi EC, Aksoy AN. Balloon Tamponade in the Management of Postpartum Hemorrhage: Three Years of Experience in a Single Center. Open J Obstet Gynecol 2016;06:698–704. doi:10.4236/ojog.2016.612087
28 Martin E, Legendre G, Bouet PE, et al. Maternal outcomes after uterine balloon tamponade for postpartum hemorrhage. Acta Obstet Gynecol Scand 2015;94:399–404. doi:10.1111/aogs.12591
29 Ogoyama M, Takahashi H, Usui R, et al. Hemostatic effect of intrauterine balloon for postpartum hemorrhage with special reference to concomitant use of “holding the cervix” procedure (Matsubara). Eur J Obstet Gynecol Reprod Biol 2017;210:281–5. doi:10.1016/j.ejogr.2017.01.012
30 Sun M, Einerson BD, Schneider P, et al. Is There an Association between Indication for Intrauterine Balloon Tamponade and Balloon Failure? Am J Perinatol 2017;34:164–8. doi:10.1055/s-0036-1585084
31 Ramanathan A, Eckardt MJ, Nelson BD, et al. Safety of a condom uterine balloon tamponade (ESM-UBT) device for uncontrolled primary postpartum hemorrhage among facilities in Kenya and Sierra Leone. BMC Pregnancy Childbirth 2018;18:1–7. doi:10.1186/s12884-018-1808-z
32 Burke TF, Ahn R, Nelson BD, et al. A postpartum haemorrhage package with condom uterine balloon tamponade: a prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. BJOG An Int J Obstet Gynaecol 2016;123:1532–40. doi:10.1111/1471-0528.13550
33 Burke TF, Danso-Bamfo S, Guha M, et al. Shock progression and survival after use of a condom uterine balloon tamponade package in women with uncontrolled postpartum hemorrhage. Int J Gynecol Obstet 2017;139:34–8. doi:10.1002/ijog.12251
34 Joseph CM, Bhatia G, Abraham V, et al. Obstetric admissions to tertiary level intensive care unit – Prevalence, clinical characteristics and outcomes. Indian J Anaesth 2018;62:940–4. doi:10.4103/ija.IJA_537_18
35 Rastogi A, Zahid. Postpartum haemorrhage | National Health Portal Of India. Natl. Heal. Portal India. 2017.https://www.nhp.gov.in/disease/gynaecology-and-obstetrics/postpartum-
haemorrhage (accessed 20 Jul 2020).

36 Carroli G, Cuesta C, Abalos E, et al. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract. Res. Clin. Obstet. Gynaecol. 2008;22:999–1012. doi:10.1016/j.bpobgyn.2008.08.004

37 Dutta D. Textbook of Obstetrics. 2015.

38 Tasneem F, Sirsam S, Shanbhag V. Clinical study of post partum haemorrhage from a teaching hospital in Maharashtra, India. Int J Reprod Contraception, Obstet Gynecol 2017;6:2366. doi:10.18203/2320-1770.ijrcog20172314

39 International Institute for Population Sciences. National Family Health Survey (NFHS-4) 2015-16 India. Int Inst Popul Sci ICF 2017::1–192. doi:kwm120 [pii]10.1093/aje/kwm120
### Table 1.1: Details of the studies included in targeted literature review for the three UBT devices

| Authors          | Study design  | Condom-UBT PPH success rate | Condom-UBT Atonic PPH success rate | Reference |
|------------------|---------------|-----------------------------|-----------------------------------|-----------|
| Darwish et al.   | RCT           | 28/33 (84.8)                | 28/33 (84.8)                      | [1]       |
| Tindell et al.   | Systematic Review | 186/193 (96.4)            | NR                               | [2]       |
| Santhanam et al. | Prospective   | 59/61 (96.7)                | 59/61 (96.7)                      | [3]       |
| Rathore et al.   | Prospective   | 17/18 (94.4)                | NR                               | [4]       |
| Aderoba et al.   | Prospective   | 203/229 (88.6)             | 193/214 (90.2)                    | [5]       |
| Mishra et al.    | Prospective   | 59/60 (98.3)                | NR                               | [6]       |
| Kandeel et al.   | Prospective   | 48/50 (96.0)                | 28/28 (100)                       | [7]       |
| Anger et al.     | RCT           | 56/64 (87.5)                | NR                               | [8]       |
| Dumont et al.    | RCT           | 48/57 (84.2)                | NR                               | [9]       |
| Lohano et al.    | Prospective   | 126/139 (90.6)             | 126/139 (90.6)                    | [10]      |
| Hasabe et al.    | Prospective   | 34/36 (94.4)                | NR                               | [11]      |
| Yadav et al.     | Prospective   | 117/122 (95.9)             | 117/122 (95.9)                    | [12]      |

### Bakri-UBT

| Authors          | Study design  | Bakri-UBT PPH success rate | Bakri-UBT Atonic PPH success rate | Reference |
|------------------|---------------|---------------------------|----------------------------------|-----------|
| Darwish et al.   | RCT           | 30/33 (90.9)              | 30/33 (90.9)                      | [1]       |
| Revert et al.    | Prospective   | 188/226 (83.2)            | 155/183 (84.7)                    | [13]      |
| Brown et al.     | Prospective   | 55/58 (94.8)              | 52/55 (94.5)                      | [14]      |
| Vintejoux et al. | Retrospective | 25/36 (69.4)              | 25/36 (69.4)                      | [15]      |
| Guo et al.       | Retrospective | 288/305 (94.4)            | 131/142 (92.3)                    | [16]      |
| Mathur et al.    | Retrospective | 40/49 (81.6)              | 14/17 (82.4)                      | [17]      |
| Wang et al.      | Prospective   | 373/407 (91.6)            | 373/407 (91.6)                    | [18]      |
| Alkis et al.     | Retrospective | 43/47 (91.5)              | NR                               | [19]      |
| Kaya et al.      | Prospective   | 34/45 (75.6)              | 27/34 (79.4)                      | [20]      |
| Laas et al.      | Before and after | 37/43 (86)               | 37/43 (86)                        | [21]      |
| Olsen et al.     | Retrospective | 25/37 (67.6)              | 17/24 (70.8)                      | [22]      |
| Kong et al.      | Retrospective | 59/81 (72.8)              | 37/59 (62.7)                      | [23]      |
| Study               | Design               | Cases | Survival Rate (95%) | Survival Rate (95%) | Reference |
|---------------------|----------------------|-------|---------------------|---------------------|-----------|
| Cetin et al.        | Retrospective        | 29/39 | 74.4                | 29/39 (74.4)        | [24]      |
| Gauchotte et al.    | Before and after     | 35/38 | 92.1                | NR                  | [25]      |
| Grange et al.       | Retrospective        | 80/108| 74.1                | 26/39 (66.7)        | [26]      |
| Kadioglu et al.     | Retrospective        | 42/50 | 84                  | NR                  | [27]      |
| Martin et al.       | Retrospective        | 32/49 | 65.3                | 28/42 (66.7)        | [28]      |
| Ogoyama et al.      | Retrospective        | 66/71 | 93                  | 31/32 (96.9)        | [29]      |
| Son et al.          | Retrospective        | 239/306| 78.1               | 190/241 (78.8)      | [30]      |
| ESM-UBT             |                      |       |                     |                     |           |
| Ramanathan et al.   | Prospective/Retrospective case series | 189/201 (94) * | NR                  | [31]      |
| Burke et al.        | Prospective case series | 190/201 (94.5) * | NR                  | [32]      |
| Burke et al.        | Prospective case series | 298/306 (97.4) * | 298/306 (97.4)      | [33]      |

* - Reported survival rates
NR – Not reported
REFERENCES

1. Darwish AM, Abdallah MM, Shaaban OM, et al. Bakri balloon versus condom-loaded Foley’s catheter for treatment of atonic postpartum hemorrhage secondary to vaginal delivery: a randomized controlled trial. *J Matern Neonatal Med* 2018;31:747–53. doi:10.1080/14767058.2017.1297407

2. Tindell K, Garfinkel R, Abu-Haydar E, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage in resource-poor settings: A systematic review. *BJOG* An Int. J. Obstet. Gynaecol. 2013;120:5–14. doi:10.1111/j.1471-0528.2012.03454.x

3. Santhanam R, Viswanathan RM, V. P. Condom tamponade in the management of atonic postpartum hemorrhage. *Int J Reprod Contraception, Obstet Gynecol* 2018;7:2276. doi:10.18203/2320-1770.ijrcog20182335

4. Rathore AM, Gupta S, Manakata U, et al. Uterine tamponade using condom catheter balloon in the management of non-traumatic postpartum hemorrhage. *J Obstet Gynaecol Res* 2012;38:1162–7. doi:10.1111/j.1447-0756.2011.01843.x

5. Aderoba A, Olagbuji B, Akintan A, et al. Condom-catheter tamponade for the treatment of postpartum haemorrhage and factors associated with success: a prospective observational study. *BJOG* An Int J Obstet Gynaecol 2017;124:1764–71. doi:10.1111/1471-0528.14361

6. Mishra N, Gulabani K, Agrawal S, et al. Efficacy and Feasibility of Chhattisgarh Balloon and Conventional Condom Balloon Tamponade: A 2-Year Prospective Study. *J Obstet Gynecol India* 2019;69:133–41. doi:10.1007/s13224-018-1185-6

7. Kandeel M, Sanad Z, Ellakwa H, et al. Management of postpartum hemorrhage with intrauterine balloon tamponade using a condom catheter in an Egyptian setting. *Int J Gynecol Obstet* 2016;135:272–5. doi:10.1016/j.ijgo.2016.06.018

8. Anger HA, Dabash R, Durocher J, et al. The effectiveness and safety of introducing condom-catheter uterine balloon tamponade for postpartum haemorrhage at secondary level hospitals in Uganda, Egypt and Senegal: a stepped wedge, cluster-randomised trial. *BJOG* An Int J Obstet Gynaecol 2019;126:1612–21. doi:10.1111/1471-0528.15903

9. Dumont A, Bodin C, Hounkpatin B, et al. Uterine balloon tamponade as an adjunct to misoprostol for the treatment of uncontrolled postpartum haemorrhage: A randomised controlled trial in Benin and Mali. *BMJ Open* 2017;7:1–9. doi:10.1136/bmjopen-2017-016590

10. Lohano R, Haq G, Kazi S, et al. Intrauterine balloon tamponade for the control of postpartum hemorrhage. *J Pak Med Assoc* 2016;66:22–6.

11. Hasabe R, Gupta K, Rathode P. Use of Condom Tamponade to Manage Massive Obstetric Hemorrhage at a Tertiary Center in Rajasthan. *J Obstet Gynecol India* 2016;66:88–93. doi:10.1007/s13224-015-0790-x

12. Yadav S, Malhotra A. A prospective randomized comparative study of Misoprostol and balloon tamponade using condom catheter to prevent postpartum hemorrhage at M. Y. H., Indore, India in vaginal delivered patients. *Int J Reprod Contraception, Obstet Gynecol* 2019;8:591. doi:10.18203/2320-2320-1770.ijrcog20190290

13. Revert M, Cottenet J, Raynal P, et al. Intrauterine balloon tamponade for management of severe postpartum hemorrhage in a perinatal network: a prospective cohort study. *BJOG* An Int J Obstet Gynaecol 2017;124:1255–62. doi:10.1111/1471-0528.14382

14. Brown H, Okeyo S, Mabeya H, et al. The Bakri tamponade balloon as an adjunct treatment for refractory postpartum hemorrhage. *Int J Gynecol Obstet* 2016;135:276–80. doi:10.1016/j.ijgo.2016.06.021

15. Vintejoux E, Ulrich D, Mousty E, et al. Success factors for Bakri™ balloon usage secondary to uterine atony: A retrospective, multicentre study. *Aust New Zeal J Obstet Gynaecol* 2015;55:572–7. doi:10.1111/aob.12376

16. Guo Y, Hua R, Bian S, et al. Intrauterine Bakri Balloon and Vaginal Tamponade Combined with Abdominal Compression for the Management of Postpartum Hemorrhage. *J Obstet Gynaecol Canada* 2018;40:561–5. doi:10.1016/j.jogc.2017.08.035

17. Mathur M, Ng QJ, Tagore S. Use of Bakri balloon tamponade (BBT) for conservative management of postpartum haemorrhage: a tertiary referral centre case series. *J Obstet
Wang D, Xu S, Qiu X, et al. Early usage of Bakri postpartum balloon in the management of postpartum hemorrhage: A large prospective, observational multicenter clinical study in South China. *J Perinat Med* 2018; **46**:649–56. doi: 10.1515/jpm-2017-0249

Alkiş İ, Karaman E, Han A, et al. The fertility sparing management of postpartum hemorrhage: A series of 47 cases of Bakri balloon tamponade. *Taiwan J Obstet Gynecol* 2015; **54**:232–5. doi: 10.1016/j.tjog.2014.03.009

Kaya B, Tuten A, Daglar K, et al. Balloon tamponade for the management of postpartum uterine hemorrhage. *J Perinat Med* 2014; **42**:745–53. doi: 10.1515/jpm-2013-0336

Laas E, Bui C, Popowski T, et al. Trends in the rate of invasive procedures after the addition of the intrauterine tamponade test to a protocol for management of severe postpartum hemorrhage. *Am J Obstet Gynecol* 2012; **207**:281.e1–281.e7. doi: 10.1016/j.ajog.2012.08.028

Olsen R, Reisner DP, Benedetti TJ, et al. Bakri balloon effectiveness for postpartum hemorrhage: A ‘real world experience’. *J Matern Neonatal Med* 2013; **26**:1720–3. doi: 10.3109/14767058.2013.796354

Kong CW, To WW. Prognostic factors for the use of intrauterine balloon tamponade in the management of severe postpartum hemorrhage. *Int J Gynecol Obstet* 2018; **142**:48–53. doi: 10.1002/ijgo.12498

Çetin BA, Aydogan Mathyk B, Atis Aydin A, et al. Comparing success rates of the Hayman compression suture and the Bakri balloon tamponade. *J Matern Neonatal Med* 2019; **32**:3034–8. doi: 10.1080/14767058.2018.1455184

Gauchotte E, De La Torre M, Perdrillose-Galet E, et al. Impact of uterine balloon tamponade on the use of invasive procedures in severe postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2017; **96**:877–82. doi: 10.1111/aogs.13130

Grange J, Chatellier M, Chevè MT, et al. Predictors of failed intrauterine balloon tamponade for persistent postpartum hemorrhage after vaginal delivery. *PLoS One* 2018; **13**:1–11. doi: 10.1371/journal.pone.0206663

Kadioglu BG, Tanriverdi EC, Aksoy AN. Balloon Tamponade in the Management of Postpartum Hemorrhage: Three Years of Experience in a Single Center. *Open J Obstet Gynecol* 2016; **06**:698–704. doi: 10.4236/ojog.2016.612087

Martin E, Legendre G, Bouet PE, et al. Maternal outcomes after uterine balloon tamponade for postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2015; **94**:399–404. doi: 10.1111/aogs.12591

Ogoyama M, Takahashi H, Usui R, et al. Hemostatic effect of intrauterine tamponade with special reference to concomitant use of “holding the cervix” procedure (Matsubara). *Eur J Obstet Gynecol Reprod Biol* 2017; **210**:281–5. doi: 10.1016/j.ejogrb.2017.01.012

Son M, Einerson BD, Schneider P, et al. Is There an Association between Indication for Intrauterine Balloon Tamponade and Balloon Failure? *Am J Perinatol* 2017; **34**:164–8. doi: 10.1055/s-0036-1585084

Ramanathan A, Eckardt MJ, Nelson BD, et al. Safety of a condom uterine balloon tamponade (ESM-UBT) device for uncontrolled primary postpartum hemorrhage among facilities in Kenya and Sierra Leone. *BMC Pregnancy Childbirth* 2018; **18**:1–7. doi: 10.1186/s12884-018-1808-z

Burke TF, Ahn R, Nelson BD, et al. A postpartum haemorrhage package with condom uterine balloon tamponade: a prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. *BJOG An Int J Obstet Gynecol* 2016; **123**:1532–40. doi: 10.1111/1471-0528.13550

Burke TF, Danso-Bamfo S, Guha M, et al. Shock progression and survival after use of a condom uterine balloon tamponade package in women with uncontrolled postpartum hemorrhage. *Int J Gynecol Obstet* 2017; **139**:34–8. doi: 10.1002/ijgo.12251

Joseph CM, Bhatia G, Abraham V, et al. Obstetric admissions to tertiary level intensive care unit – Prevalence, clinical characteristics and outcomes. *Indian J Anaesth* 2018; **62**:940–4. doi: 10.4103/ija.IJA_537_18

Rastogi A, Zahid. Postpartum haemorrhage | National Health Portal Of India. Natl. Heal. Portal India. 2017.https://www.nhp.gov.in/disease/gynaecology-and-obstetrics/postpartum-
36 Carroli G, Cuesta C, Abalos E, et al. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract. Res. Clin. Obstet. Gynaecol. 2008;22:999–1012. doi:10.1016/j.bpobgyn.2008.08.004

37 Dutta D. Textbook of Obstetrics. 2015.

38 Tasneem F, Sirsam S, Shanbhag V. Clinical study of post partum haemorrhage from a teaching hospital in Maharashtra, India. Int J Reprod Contraception, Obstet Gynecol 2017;6:2366. doi:10.18203/2320-1770.ijrcog20172314

39 International Institute for Population Sciences. National Family Health Survey (NFHS-4) 2015-16 India. Int Inst Popul Sci ICF 2017;1–192. doi:kwm120 [pii]10.1093/aje/kwm120
Table 1.2: Staff time allocation parameters used in costing analysis

| Parameter                                                                 | Value in cost analysis* | Source                        |
|---------------------------------------------------------------------------|-------------------------|-------------------------------|
| Average time taken for UBT device insertion                                | 10 minutes              |                               |
| Average time taken for normal vaginal delivery in labour room              | 7.25 hours              |                               |
| Average time taken for vaginal delivery with PPH complication, controlled  | 10.25 hours             |                               |
| after medical management in LR                                             |                         |                               |
| Average time taken for UBT device retention among those controlled with    | 24 hours                |                               |
| UBT                                                                        |                         |                               |
| Average time in operation theatre for a caesarean section without         | 45 minutes              |                               |
| complications                                                             |                         |                               |
| Average time in operation theatre for a caesarean section with PPH        | 60 minutes              |                               |
| complication controlled with medical management                           |                         |                               |
| Average time in operation theatre for a caesarean section with PPH        | 75 minutes              |                               |
| complication requiring UBT insertion                                      |                         |                               |
| Average time for devascularization surgery after PPH                      | 75 minutes              |                               |
| Average time for hysterectomy after PPH                                   | 120 minutes             |                               |
| Average time spent in out-patient department                              | 12 hours/week           |                               |
| Average time spent in indoor patient management                           | 12 hours/week           |                               |
| Average time spent in operation theatre                                   | 12 hours/week           |                               |
| Average time spent in labour room                                         | 2 hours/week            |                               |
| Average time spent in administration and documentation                     | 10 hours/week           |                               |
| Average time spent in teaching and training                               | 5.15 hours/week         |                               |
| Average time spent in out-patient department                              | 12 hours/week           |                               |
| Average time spent in indoor patient management                           | 12 hours/week           |                               |
| Average time spent in operation theatre                                   | 6 hours/week            |                               |
| Average time spent in administrative work                                  | 15 hours/week           |                               |
| Average time spent in labour room by Grade 4 worker                       | 12 hours/week           |                               |
| Average time spent in operation theatre by Grade 4 worker                 | 12 hours/week           |                               |
| Mean length of stay for OBGYN patients in ICU                             | 3.47 days               | [34]                          |
| Mean length of ICU stay for PPH patients                                  | 1.5 days                | [5]                           |

Reported by senior most doctor

Reported by sister-in-charge

Reported by grade 4 worker
REFERENCES

1. Darwish AM, Abdallah MM, Shaaban OM, et al. Bakri balloon versus condom-loaded Foley’s catheter for treatment of atonic postpartum hemorrhage secondary to vaginal delivery: a randomized controlled trial. *J Matern Neonatal Med* 2018;31:747–53. doi:10.1080/14767058.2017.1297407

2. Tindell K, Garfinkel R, Abu-Haydar E, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage in resource-poor settings: A systematic review. *BJOG An Int. J. Obstet. Gynaecol.* 2013;120:5–14. doi:10.1111/j.1471-0528.2012.03454.x

3. Santhanam R, Viswanathan RM, V. P. Condom tamponade in the management of atonic postpartum hemorrhage. *Int J Reprod Contraception, Obstet Gynecol* 2018;7:2276. doi:10.18203/2320-1770.ijrcog20182335

4. Rathore AM, Gupta S, Manakta U, et al. Uterine tamponade using condom catheter balloon in the management of non-traumatic postpartum hemorrhage. *J Obstet Gynaecol Res* 2012;38:1162–7. doi:10.1111/j.1447-0756.2011.01843.x

5. Aderoba A, Olagbuji B, Akintan A, et al. Condom-catheter tamponade for the treatment of postpartum haemorrhage and factors associated with success: a prospective observational study. *BJOG An Int J Obstet Gynaecol* 2017;124:1764–71. doi:10.1111/1471-0528.14361

6. Mishra N, Gulabani K, Agrawal S, et al. Efficacy and Feasibility of Chhattisgarh Balloon and Conventional Condom Balloon Tamponade: A 2-Year Prospective Study. *J Obstet Gynecol India* 2019;69:133–41. doi:10.1007/s13224-018-1185-6

7. Kandeel M, Sanad Z, Ellakwa H, et al. Management of postpartum hemorrhage with intrauterine balloon tamponade using a condom catheter in an Egyptian setting. *Int J Gynecol Obstet* 2016;135:272–5. doi:10.1016/j.ijgo.2016.06.018

8. Anger HA, Dabash R, Durocher J, et al. The effectiveness and safety of introducing condom-catheter uterine balloon tamponade for postpartum haemorrhage at secondary level hospitals in Uganda, Egypt and Senegal: a stepped wedge, cluster-randomised trial. *BJOG An Int J Obstet Gynaecol* 2019;126:1612–21. doi:10.1111/1471-0528.15903

9. Dumont A, Bodin C, Hounkpatin B, et al. Uterine balloon tamponade as an adjunct to misoprostol for the treatment of uncontrolled postpartum haemorrhage: A randomised controlled trial in Benin and Mali. *BMJ Open* 2017;7:1–9. doi:10.1136/bmjopen-2017-016590

10. Lohano R, Haq G, Kazi S, et al. Intrauterine balloon tamponade for the control of postpartum haemorrhage. *J Pak Med Assoc* 2016;66:22–6.

11. Hasabe R, Gupta K, Rathode P. Use of Condom Tamponade to Manage Massive Obstetric Hemorrhage at a Tertiary Center in Rajasthan. *J Obstet Gynecol India* 2016;66:88–93. doi:10.1007/s13224-015-0790-x

12. Yadav S, Malhotra A. A prospective randomized comparative study of Misoprostol and balloon tamponade using condom catheter to prevent postpartum hemorrhage at M. Y. H., Indore, India in vaginal delivered patients. *Int J Reprod Contraception, Obstet Gynecol* 2019;8:591. doi:10.18203/2320-2320-1770.ijrcog20190290

13. Revert M, Cottenet J, Raynal P, et al. Intrauterine balloon tamponade for management of severe postpartum haemorrhage in a perinatal network: a prospective cohort study. *BJOG An Int J Obstet Gynaecol* 2017;124:1255–62. doi:10.1111/1471-0528.14382

14. Brown H, Okeyo S, Mabeya H, et al. The Bakri balloon tamponade as an adjunct treatment for refractory postpartum hemorrhage. *Int J Gynecol Obstet* 2016;135:276–80. doi:10.1016/j.ijgo.2016.06.021

15. Vintejoux E, Ulrich D, Moustey E, et al. Success factors for Bakri™ balloon usage secondary to uterine atony: A retrospective, multicentre study. *Aust New Z J Obstet Gynaecol* 2015;55:572–7. doi:10.1111/aio.12376

16. Guo Y, Hua R, Bian S, et al. Intrauterine Bakri Balloon and Vaginal Tamponade Combined with Abdominal Compression for the Management of Postpartum Hemorrhage. *J Obstet Gynaecol Canada* 2018;40:561–5. doi:10.1016/j.jogc.2017.08.035

17. Mathur M, Ng QJ, Tagore S. Use of Bakri balloon tamponade (BBT) for conservative management of postpartum haemorrhage: a tertiary referral centre case series. *J Obstet Gynaeol Canada* 2018;40:561–5. doi:10.1016/j.jogc.2017.08.035
18 Wang D, Xu S, Qiu X, et al. Early usage of Bakri postpartum balloon in the management of postpartum hemorrhage: A large prospective, observational multicenter clinical study in South China. *J Perinat Med* 2018;**46**:649–56. doi:10.1515/jpm-2017-0249

19 Akliş I, Karahan E, Han A, et al. The fertility sparing management of postpartum hemorrhage: A series of 47 cases of Bakri balloon tamponade. *Taiwan J Obstet Gynecol* 2015;**54**:232–5. doi:10.1016/j.tjog.2014.03.009

20 Kaya B, Tuten A, Daglar K, et al. Balloon tamponade for the management of postpartum uterine hemorrhage. *J Perinat Med* 2014;**42**:745–53. doi:10.1515/jpm-2013-0336

21 Laas E, Bui C, Popowski T, et al. Trends in the rate of invasive procedures after the addition of the intrauterine tamponade test to a protocol for management of severe postpartum hemorrhage. *Am J Obstet Gynecol* 2012;**207**:281.e1-281.e7. doi:10.1016/j.ajog.2012.08.028

22 Olsen R, Reisner DP, Benedetti TJ, et al. Bakri balloon effectiveness for postpartum hemorrhage: A ‘real world experience’. *J Matern Neonatal Med* 2013;**26**:1720–3. doi:10.3109/14767058.2013.796354

23 Kong CW, To WW. Prognostic factors for the use of intrauterine balloon tamponade in the management of severe postpartum hemorrhage. *Int J Gynecol Obstet* 2018;**142**:48–53. doi:10.1002/ijo.12498

24 Çetin BA, Aydogan Mathyk B, Atis Aydin A, et al. Comparing success rates of the Hayman compression suture and the Bakri balloon tamponade. *J Matern Neonatal Med* 2019;**32**:3034–8. doi:10.1080/14767058.2018.1455184

25 Gauchotte E, De La Torre M, Perdrillo-Galet E, et al. Impact of uterine balloon tamponade on the use of invasive procedures in severe postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2017;**96**:877–82. doi:10.1111/aogs.13130

26 Grange J, Chatellier M, Chevè MT, et al. Predictors of failed intrauterine balloon tamponade for persistent postpartum hemorrhage after vaginal delivery. *PLoS One* 2018;**13**:1–11. doi:10.1371/journal.pone.0206663

27 Kadioglu BG, Tanriverdi EC, Aksoy AN. Balloon Tamponade in the Management of Postpartum Hemorrhage: Three Years of Experience in a Single Center. *Open J Obstet Gynecol* 2016;**06**:698–704. doi:10.4236/ojog.2016.612087

28 Martin E, Legendre G, Bouet PE, et al. Maternal outcomes after uterine balloon tamponade for postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2015;**94**:399–404. doi:10.1111/aogs.12591

29 Ogoyama M, Takahashi H, Usui R, et al. Hemostatic effect of intrauterine tamponade for postpartum hemorrhage with special reference to concomitant use of “holding the cervix” procedure (Matsubara). *Eur J Obstet Gynecol Reprod Biol* 2017;**210**:281–5. doi:10.1016/j.ejogrb.2017.01.012

30 Son M, Einerson BD, Schneider P, et al. Is There an Association between Indication for Intrauterine Balloon Tamponade and Balloon Failure? *Am J Perinatol* 2017;**34**:164–8. doi:10.1055/s-0036-1585084

31 Ramanathan A, Eckardt MJ, Nelson BD, et al. Safety of a condom uterine balloon tamponade (ESM-UBT) device for uncontrolled primary postpartum hemorrhage among facilities in Kenya and Sierra Leone. *BMC Pregnancy Childbirth* 2018;**18**:1–7. doi:10.1186/s12884-018-1808-z

32 Burke TF, Ahn R, Nelson BD, et al. A postpartum haemorrhage package with condom uterine balloon tamponade: a prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. *BJOG An Int J Obstet Gynaecol* 2016;**123**:1532–40. doi:10.1111/1471-0528.13550

33 Burke TF, Danso-Bamfo S, Guha M, et al. Shock progression and survival after use of a condom uterine balloon tamponade package in women with uncontrolled postpartum hemorrhage. *Int J Gynecol Obstet* 2017;**139**:34–8. doi:10.1002/ijgo.12251

34 Joseph CM, Bhatia G, Abraham V, et al. Obstetric admissions to tertiary level intensive care unit – Prevalence, clinical characteristics and outcomes. *Indian J Anaesth* 2018;**62**:940–4. doi:10.4103/ija.IJA_537_18

35 Rastogi A, Zahid. Postpartum haemorrhage | National Health Portal Of India. Natl. Heal. Portal India. 2017.https://www.nhp.gov.in/disease/gynaecology-and-obstetrics/postpartum-
haemorrhage (accessed 20 Jul 2020).

36 Carroli G, Cuesta C, Abalos E, et al. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract. Res. Clin. Obstet. Gynaecol. 2008;22:999–1012. doi:10.1016/j.bpo.2008.08.004

37 Dutta D. Textbook of Obstetrics. 2015.

38 Tasneem F, Sirsam S, Shanbhag V. Clinical study of post partum haemorrhage from a teaching hospital in Maharashtra, India. Int J Reprod Contraception, Obstet Gynecol 2017;6:2366. doi:10.18203/2320-1770.ijrcog20172314

39 International Institute for Population Sciences. National Family Health Survey (NFHS-4) 2015-16 India. Int Inst Popul Sci ICF 2017;1–192. doi:kwm120 [pii]10.1093/aje/kwm120
Table 1.3: Literature based event probabilities used for PPH utilization calculation of healthcare facilities

| Input                                                      | Value  | Reference |
|------------------------------------------------------------|--------|-----------|
| PPH incidence in vaginal delivery                          | 3 percent | [35,36]   |
| PPH incidence in caesarean delivery                        | 6 percent | [35,36]   |
| Atonic PPH incidence                                       | 80 percent | [37]       |
| Atonic PPH controlled with medical management              | 90 percent | [38]       |
| Clinical effectiveness of condom-UBT device in controlling atonic PPH | 92.3 percent | Calculated from literature review of 33 studies reported in Table 1.1 |
| Clinical effectiveness of ESM-UBT device in controlling atonic PPH | 95.3 percent* | Calculated from literature review of 33 studies reported in Table 1.1 |
| Clinical effectiveness of condom-UBT device in controlling atonic PPH | 84.3 percent | Calculated from literature review of 33 studies reported in Table 1.1 |
| Probability of stepwise devascularization procedure for uncontrolled atonic PPH cases after UBT insertion | 0.85 | [38] |
| Probability of obstetric hysterectomy for uncontrolled atonic PPH cases after UBT insertion | 0.15 | [38] |
| Probability of delivery at primary care level              | 0.19 | [39] |
| Probability of delivery at secondary care level            | 0.33 | [39] |
| Probability of delivery at tertiary care level             | 0.48 | [39] |

* - Estimated from limited evidence from 3 case-series studies reported in Table 1.1

PPH incidence rate in vaginal/caesarean section delivery was applied to reported number of deliveries at each health facility (Table 1.4) to estimate number of PPH and thus proportional atonic PPH cases at the facility. Proportion of these atonic PPH cases uncontrolled after medical and supportive management were eligible for UBT device insertion. Literature review based clinical effectiveness of individual UBT device determined number of patients consequently needing conservative (devascularization) or obstetric hysterectomy surgical intervention at each facility. Table 1.4 shows results of these calculations for each chosen facility.
REFERENCES

1 Darwish AM, Abdallah MM, Shaaban OM, et al. Bakri balloon versus condom-loaded Foley’s catheter for treatment of atonic postpartum hemorrhage secondary to vaginal delivery: a randomized controlled trial. J Matern Neonatal Med 2018;31:747–53. doi:10.1080/14767058.2017.1297407

2 Tindell K, Garfinkel R, Abu-Haydar E, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage in resource-poor settings: A systematic review. BJOG An Int. J. Obstet. Gynaecol. 2013;120:5–14. doi:10.1111/j.1471-0528.2012.03454.x

3 Santhanam R, Viswanathan RM, V. P. Condom tamponade in the management of atonic postpartum hemorrhage. Int J Reprod Contraception, Obstet Gynecol 2018;7:2276. doi:10.18203/2320-1770.ijrcog20182335

4 Rathore AM, Gupta S, Manaktala U, et al. Uterine tamponade using condom catheter balloon in the management of non-traumatic postpartum hemorrhage. J Obstet Gynaecol Res 2012;38:1162–7. doi:10.1111/j.1447-0756.2011.01843.x

5 Aderoba A, Olagbuji B, Akintan A, et al. Condom-catheter tamponade for the treatment of postpartum haemorrhage and factors associated with success: a prospective observational study. BJOG An Int J Obstet Gynaecol 2017;124:1764–71. doi:10.1111/1471-0528.14361

6 Mishra N, Gulabani K, Agrawal S, et al. Efficacy and Feasibility of Chhattisgarh Balloon and Conventional Condom Balloon Tamponade: A 2-Year Prospective Study. J Obstet Gynecol India 2019;69:133–41. doi:10.1007/s13224-018-1185-6

7 Kandeel M, Sanad Z, Ellakwa H, et al. Management of postpartum hemorrhage with intrauterine balloon tamponade using a condom catheter in an Egyptian setting. Int J Gynecol Obstet 2016;135:272–5. doi:10.1016/j.ijgo.2016.06.018

8 Anger HA, Dabash R, Durocher J, et al. The effectiveness and safety of introducing condom-catheter uterine balloon tamponade for postpartum haemorrhage at secondary level hospitals in Uganda, Egypt and Senegal: a stepped wedge, cluster-randomised trial. BJOG An Int J Obstet Gynaecol 2019;126:1612–21. doi:10.1111/1471-0528.15903

9 Dumont A, Bodin C, Hounkpatin B, et al. Intrauterine balloon tamponade as an adjunct to misoprostol for the treatment of uncontrolled postpartum haemorrhage: A randomised controlled trial in Benin and Mali. BJM Open 2017;7:1–9. doi:10.1136/bmjopen-2017-016590

10 Lohano R, Haq G, Kazi S, et al. Intrauterine balloon tamponade for the control of postpartum haemorrhage. J Pak Med Assoc 2016;66:22–6.

11 Hasabe R, Gupta K, Rathode P. Use of Condom Tamponade to Manage Massive Obstetric Hemorrhage at a Tertiary Center in Rajasthan. J Obstet Gynecol India 2016;66:88–93. doi:10.1007/s13224-015-0790-x

12 Yadav S, Malhotra A. A prospective randomized comparative study of Misoprostol and balloon tamponade using condom catheter to prevent postpartum hemorrhage at M. Y. H., Indore, India in vaginal delivered patients. Int J Reprod Contraception, Obstet Gynecol 2019;8:591. doi:10.18203/2320-1770.ijrcog20190290

13 Revert M, Cottenet J, Raynal P, et al. Intrauterine balloon tamponade for management of severe postpartum haemorrhage in a perinatal network: a prospective cohort study. BJOG An Int J Obstet Gynaecol 2017;124:1255–62. doi:10.1111/1471-0528.14382

14 Brown H, Okeyo S, Mabeya H, et al. The Bakri tamponade balloon as an adjunct treatment for refractory postpartum hemorrhage. Int J Gynecol Obstet 2016;135:276–80. doi:10.1016/j.ijgo.2016.06.021

15 Vintejoux E, Ulrich D, Mousty E, et al. Success factors for Bakri™ balloon usage secondary to uterine atony: A retrospective, multicentre study. Aust New Zeal J Obstet Gynaecol 2015;55:572–7. doi:10.1111/aobj.12376

16 Guo Y, Hua R, Bian S, et al. Intrauterine Bakri Balloon and Vaginal Tamponade Combined with Abdominal Compression for the Management of Postpartum Hemorrhage. J Obstet Gynaecol Canada 2018;40:561–5. doi:10.1016/j.jogc.2017.08.035

17 Mathur M, Ng QJ, Tagore S. Use of Bakri balloon tamponade (BBT) for conservative management of postpartum haemorrhage: a tertiary referral centre case series. J Obstet
Wang D, Xu S, Qiu X, et al. Early usage of Bakri postpartum balloon in the management of postpartum hemorrhage: A large prospective, observational multicenter clinical study in South China. *J Perinat Med* 2018;46:649–56. doi:10.1515/jpm-2017-0249

Alkiş I, Karaman E, Han A, et al. The fertility sparing management of postpartum hemorrhage: A series of 47 cases of Bakri balloon tamponade. *Taiwan J Obstet Gynecol* 2015;54:232–5. doi:10.1016/j.tjog.2014.03.009

Kaya B, Tuten A, Daglar K, et al. Balloon tamponade for the management of postpartum uterine hemorrhage. *J Perinat Med* 2014;42:745–53. doi:10.1515/jpm-2013-0336

Laas E, Bui C, Popowski T, et al. Trends in the rate of invasive procedures after the addition of the intrauterine tamponade test to a protocol for management of severe postpartum hemorrhage. *Am J Obstet Gynecol* 2012;207:281.e1-281.e7. doi:10.1016/j.ajog.2012.08.028

Olsen R, Reisner DP, Benedetti TJ, et al. Bakri balloon effectiveness for postpartum hemorrhage: A ‘real world experience’. *J Matern Neonatal Med* 2013;26:1720–3. doi:10.3109/14767058.2013.796354

Kong CW, To WW. Prognostic factors for the use of intrauterine balloon tamponade in the management of severe postpartum hemorrhage. *Int J Gynecol Obstet* 2018;142:48–53. doi:10.1002/ijgo.12498

Çetin BA, Aydogan Mathyk B, Atis Aydin A, et al. Comparing success rates of the Hayman compression suture and the Bakri balloon tamponade. *J Matern Neonatal Med* 2019;32:3034–8. doi:10.1080/14767058.2018.1455184

Gauchotte E, De La Torre M, Perdriolle-Galet E, et al. Impact of uterine balloon tamponade on the use of invasive procedures in severe postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2017;96:877–82. doi:10.1111/aogs.13130

Grange J, Chatellier M, Chevé MT, et al. Predictors of failed intrauterine balloon tamponade for persistent postpartum hemorrhage after vaginal delivery. *PLoS One* 2018;13:1–11. doi:10.1371/journal.pone.0206663

Kadioglu BG, Tanriverdi EC, Aksoy AN. Balloon Tamponade in the Management of Postpartum Hemorrhage: Three Years of Experience in a Single Center. *Open J Obstet Gynecol* 2016;06:698–704. doi:10.4236/ojog.2016.612087

Martin E, Legendre G, Bouet PE, et al. Maternal outcomes after uterine balloon tamponade for postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2015;94:394–404. doi:10.1111/aogs.12591

Ogoyama M, Takahashi H, Usui R, et al. Hemostatic effect of intrauterine balloon for postpartum hemorrhage with special reference to concomitant use of “holding the cervix” procedure (Matsubara). *Eur J Obstet Gynecol Reprod Biol* 2017;210:281–5. doi:10.1016/j.ejogrb.2017.01.012

Son M, Einerson BD, Schneider P, et al. Is There an Association between Indication for Intrauterine Balloon Tamponade and Balloon Failure? *Am J Perinatol* 2017;34:164–8. doi:10.1055/s-0036-1585084

Ramanathan A, Eckardt MJ, Nelson BD, et al. Safety of a condom uterine balloon tamponade (ESM-UBT) device for uncontrolled primary postpartum hemorrhage among facilities in Kenya and Sierra Leone. *BMC Pregnancy Childbirth* 2018;18:1–7. doi:10.1186/s12884-018-1808-z

Burke TF, Ahn R, Nelson BD, et al. A postpartum haemorrhage package with condom uterine balloon tamponade: a prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. *BJOG An Int J Obstet Gynaecol* 2016;123:1532–40. doi:10.1111/1471-0528.13550

Burke TF, Danso-Bamfo S, Guha M, et al. Shock progression and survival after use of a condom uterine balloon tamponade package in women with uncontrolled postpartum hemorrhage. *Int J Gynecol Obstet* 2017;139:34–8. doi:10.1002/ijgo.12251

Joseph CM, Bhatia G, Abraham V, et al. Obstetric admissions to tertiary level intensive care unit – Prevalence, clinical characteristics and outcomes. *Indian J Anaesth* 2018;62:940–4. doi:10.4103/ija.IJA_537_18

Rastogi A, Zahid. Postpartum haemorrhage | National Health Portal Of India. Natl. Heal. Portal India. 2017.https://www.nhp.gov.in/disease/gynaecology-and-obstetrics/postpartum-
haemorrhage (accessed 20 Jul 2020).

36 Carroli G, Cuesta C, Abalos E, et al. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract. Res. Clin. Obstet. Gynaecol. 2008;22:999–1012. doi:10.1016/j.bpobgyn.2008.08.004

37 Dutta D. Textbook of Obstetrics. 2015.

38 Tasneem F, Sirsam S, Shanbhag V. Clinical study of post partum haemorrhage from a teaching hospital in Maharashtra, India. Int J Reprod Contraception, Obstet Gynecol 2017;6:2366. doi:10.18203/2320-1770.ijrcog20172314

39 International Institute for Population Sciences. National Family Health Survey (NFHS-4) 2015-16 India. Int Inst Popul Sci ICF 2017::1–192. doi:kwm120 [pii]10.1093/aje/kwm120
Table 1.4: Utilization of services for atonic PPH at chosen health facilities of Maharashtra based on primary collected data and event probabilities from literature

| Type of Health facility | Mode of Delivery | Annual number of deliveries | Atonic PPH cases | Atonic PPH controlled with medical management | Cases requiring UBT insertion | Controlled with UBT insertion | Cases requiring further intervention | Condom Bakri ESM | Condom Bakri ESM |
|-------------------------|------------------|----------------------------|------------------|---------------------------------------------|-----------------------------|-------------------------------|----------------------------------------|----------------|----------------|
| PHC                     | Vaginal          | 494                        | 11.86            | 10.67                                       | 1.18                        | 1.09                          | 0.09                                   | 1.00           | 1.19           |
|                         |                  |                            |                  |                                             |                             |                               |                                        |                |                |
| SDH                     | Vaginal          | 1526                       | 36.62            | 32.96                                       | 3.66                        | 3.41                          | 3.41                                   | 0.57           | 0.17           |
|                         | Cesarean         | 330                        | 15.84            | 14.26                                       | 1.58                        | 1.47                          | 1.34                                   | 0.25           | 0.07           |
|                         |                  |                            |                  |                                             |                             |                               |                                        |                |                |
| DH                      | Vaginal          | 2986                       | 71.66            | 64.49                                       | 7.17                        | 6.66                          | 6.04                                   | 0.34           | 0.13           |
|                         | Cesarean         | 1045                       | 50.16            | 45.14                                       | 5.02                        | 4.66                          | 4.23                                   | 0.24           | 0.07           |
|                         |                  |                            |                  |                                             |                             |                               |                                        |                |                |
| Medical college         | Vaginal          | 2202                       | 52.84            | 47.56                                       | 5.28                        | 4.87                          | 4.44                                   | 0.37           | 0.25           |
|                         | Cesarean         | 1141                       | 54.76            | 49.29                                       | 5.47                        | 5.05                          | 4.61                                   | 0.42           | 0.25           |
REFERENCES

1 Darwish AM, Abdallah MM, Shaaban OM, et al. Bakri balloon versus condom-loaded Foley’s catheter for treatment of atonic postpartum hemorrhage secondary to vaginal delivery: a randomized controlled trial. J Matern Neonatal Med 2018;31:747–53. doi:10.1080/14767058.2017.1297407

2 Tindell K, Garfinkel R, Abu-Haydar E, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage in resource-poor settings: A systematic review. BJOG An Int. J. Obstet. Gynaecol. 2013;120:5–14. doi:10.1111/j.1471-0528.2012.03454.x

3 Santhanam R, Viswanathan RM, V. P. Condom tamponade in the management of atonic postpartum hemorrhage. Int J Reprod Contraception, Obstet Gynecol 2018;7:2276. doi:10.18203/2320-1770.ijrcog20182335

4 Rathore AM, Gupta S, Manakta U, et al. Uterine tamponade using condom catheter balloon in the management of non-traumatic postpartum hemorrhage. J Obstet Gynaecol Res 2012;38:1162–7. doi:10.1111/j.1447-0756.2011.01843.x

5 Aderoba A, Olagbuji B, Akintan A, et al. Condom-catheter tamponade for the treatment of postpartum haemorrhage and factors associated with success: a prospective observational study. BJOG An Int J Obstet Gynaecol 2017;124:1764–71. doi:10.1111/1471-0528.14361

6 Mishra N, Gulabani K, Agrawal S, et al. Efficacy and Feasibility of Chhattisgarh Balloon and Conventional Condom Balloon Tamponade: A 2-Year Prospective Study. J Obstet Gynecol India 2019;69:133–41. doi:10.1007/s13224-018-1185-6

7 Kandeel M, Sanad Z, Ellakwa H, et al. Management of postpartum hemorrhage with intrauterine balloon tamponade using a condom catheter in an Egyptian setting. Int J Gynecol Obstet 2016;135:272–5. doi:10.1016/j.ijigo.2016.06.018

8 Anger HA, Dabash R, Durocher J, et al. The effectiveness and safety of introducing condom-catheter uterine balloon tamponade for postpartum haemorrhage at secondary level hospitals in Uganda, Egypt and Senegal: a stepped wedge, cluster-randomised trial. BJOG An Int J Obstet Gynaecol 2019;126:1612–21. doi:10.1111/1471-0528.15903

9 Dumont A, Bodin C, Hounkpatin B, et al. Uterine balloon tamponade as an adjunct to misoprostol for the treatment of uncontrolled postpartum haemorrhage: A randomised controlled trial in Benin and Mali. BJM Open 2017;7:1–9. doi:10.11136/bmjopen-2017-016590

10 Lohano R, Haq G, Kazi S, et al. Intrauterine balloon tamponade for the control of postpartum haemorrhage. J Pak Med Assoc 2016;66:22–6.

11 Hasabe R, Gupta K, Rathode P. Use of Condom Tamponade to Manage Massive Obstetric Hemorrhage at a Tertiary Center in Rajasthan. J Obstet Gynecol India 2016;66:88–93. doi:10.1007/s13224-015-0790-x

12 Yadav S, Malhotra A. A prospective randomized comparative study of Misoprostol and balloon tamponade using condom catheter to prevent postpartum hemorrhage at M. Y. H., Indore, India in vaginal delivered patients. Int J Reprod Contraception, Obstet Gynecol 2019;8:591. doi:10.18203/2320-2320-1770.ijrcog20190290

13 Revert M, Cottenet J, Raynal P, et al. Intrauterine balloon tamponade for management of severe postpartum haemorrhage in a perinatal network: a prospective cohort study. BJOG An Int J Obstet Gynaecol 2017;124:1255–62. doi:10.1111/1471-0528.14382

14 Brown H, Okeyo S, Mabeya H, et al. The Bakri tamponade balloon as an adjunct treatment for refractory postpartum hemorrhage. Int J Gynecol Obstet 2016;135:276–80. doi:10.1016/j.ijigo.2016.06.021

15 Vintejoux E, Ulrich D, Moustey E, et al. Success factors for Bakri balloon usage secondary to uterine atony: A retrospective, multicentre study. Aust New Zealand J Obstet Gynaecol 2015;55:572–7. doi:10.1111/año.12376

16 Guo Y, Hua R, Bian S, et al. Intrauterine Bakri Balloon and Vaginal Tamponade Combined with Abdominal Compression for the Management of Postpartum Hemorrhage. J Obstet Gynaecol Canada 2018;40:561–5. doi:10.1016/j.jogc.2017.08.035

17 Mathur M, Ng QJ, Tagore S. Use of Bakri balloon tamponade (BBT) for conservative management of postpartum haemorrhage: a tertiary referral centre case series. J Obstet

Shetty SS, et al. BMJ Open 2021; 11:e042389. doi: 10.1136/bmjopen-2020-042389
Wang D, Xu S, Qiu X, et al. Early usage of Bakri postpartum balloon in the management of postpartum hemorrhage: A large prospective, observational multicenter clinical study in South China. *J Perinat Med* 2018;46:649–56. doi: 10.1515/jpm-2017-0249

Alkış I, Karaman E, Han A, et al. The fertility sparing management of postpartum hemorrhage: A series of 47 cases of Bakri balloon tamponade. *Taiwan J Obstet Gynecol* 2015;54:232–5. doi: 10.1016/j.tjog.2014.03.009

Kaya B, Tuten A, Daglar K, et al. Balloon tamponade for the management of postpartum uterine hemorrhage. *J Perinat Med* 2014;42:745–53. doi: 10.1515/jpm-2013-0336

Laas E, Bui C, Popowski T, et al. Trends in the rate of invasive procedures after the addition of the intrauterine tamponade test to a protocol for management of severe postpartum hemorrhage. *Am J Obstet Gynecol* 2012;207:281.e1-281.e7. doi: 10.1016/j.ajog.2012.08.028

Olsen R, Reisner DP, Benedetti TJ, et al. Bakri balloon effectiveness for postpartum hemorrhage: A ‘real world experience’. *J Matern Neonatal Med* 2013;26:1720–3. doi: 10.3109/14767058.2013.796354

Kong CW, To WW. Prognostic factors for the use of intrauterine balloon tamponade in the management of severe postpartum hemorrhage. *Int J Gynecol Obstet* 2018;142:48–53. doi: 10.1002/ijgo.12498

Çetin BA, Aydogan Mathyk B, Atis Aydin A, et al. Comparing success rates of the Hayman compression suture and the Bakri balloon tamponade. *J Matern Neonatal Med* 2019;32:3034–8. doi: 10.1080/14767058.2018.1455184

Gauchotte E, De La Torre M, Perdriolle-Galet E, et al. Impact of uterine balloon tamponade on the use of invasive procedures in severe postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2017;96:877–82. doi: 10.1111/aogs.13130

Grange J, Chatellier M, Chevé MT, et al. Predictors of failed intrauterine balloon tamponade for persistent postpartum hemorrhage after vaginal delivery. *PLoS One* 2018;13:1–11. doi: 10.1371/journal.pone.0206663

Kadioglu BG, Tanriverdi EC, Aksoy AN. Balloon Tamponade in the Management of Postpartum Hemorrhage: Three Years of Experience in a Single Center. *Open J Obstet Gynecol* 2016;06:698–704. doi: 10.4236/ojog.2016.612087

Martin E, Legendre G, Bouet PE, et al. Maternal outcomes after uterine balloon tamponade for postpartum hemorrhage. *Acta Obstet Gynecol Scand* 2015;94:399–404. doi: 10.1111/aogs.12591

Ogoyama M, Takahashi H, Usui R, et al. Hemostatic effect of intrauterine balloon for postpartum hemorrhage with special reference to concomitant use of “holding the cervix” procedure (Matsubara). *Eur J Obstet Gynecol Reprod Biol* 2017;210:281–5. doi: 10.1016/j.ejogrb.2017.01.012

Son M, Einerson BD, Schneider P, et al. Is There an Association between Indication for Intrauterine Balloon Tamponade and Balloon Failure? *Am J Perinatol* 2017;34:164–8. doi: 10.1055/s-0036-1585084

Ramanathan A, Eckardt MJ, Nelson BD, et al. Safety of a condom uterine balloon tamponade (ESM-UBT) device for uncontrolled primary postpartum hemorrhage among facilities in Kenya and Sierra Leone. *BMC Pregnancy Childbirth* 2018;18:1–7. doi: 10.1186/s12884-018-1808-z.

Burke TF, Ahn R, Nelson BD, et al. A postpartum haemorrhage package with condom uterine balloon tamponade: a prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. *BJOG An Int J Obstet Gynaecol* 2016;123:1532–40. doi: 10.1111/1471-0528.13550

Burke TF, Danso-Bamfo S, Guha M, et al. Shock progression and survival after use of a condom uterine balloon tamponade package in women with uncontrolled postpartum hemorrhage. *Int J Gynecol Obstet* 2017;139:34–8. doi: 10.1002/ijgo.12251

Joseph CM, Bhatia G, Abraham V, et al. Obstetric admissions to tertiary level intensive care unit – Prevalence, clinical characteristics and outcomes. *Indian J Anaesth* 2018;62:940–4. doi: 10.4103/ija.IJA_537_18

Rastogi A, Zahid. Postpartum haemorrhage | National Health Portal Of India. Natl. Heal. Portal India. 2017.https://www.nhp.gov.in/disease/gynaecology-and-obstetrics/postpartum-
haemorrhage (accessed 20 Jul 2020).

36 Carroli G, Cuesta C, Abalos E, et al. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract. Res. Clin. Obstet. Gynaecol. 2008;22:999–1012. doi:10.1016/j.bobgyn.2008.08.004

37 Dutta D. Textbook of Obstetrics. 2015.

38 Tasneem F, Sirsam S, Shanbhag V. Clinical study of post partum haemorrhage from a teaching hospital in Maharashtra, India. Int J Reprod Contraception, Obstet Gynecol 2017;6:2366. doi:10.18203/2320-1770.ijrcog20172314

39 International Institute for Population Sciences. National Family Health Survey (NFHS-4) 2015-16 India. Int Inst Popul Sci ICF 2017;:1–192. doi:kwm120 [pii]10.1093/aje/kwm120