

Designing Capacity for High Value Healthcare:
THE IMPACT OF DESIGN ON
CLINICAL CARE IN CHILDBIRTH

Final Report

Contents

Executive Summary	3	Introduction to Results	11
<hr/>		<hr/>	
Background	4	Capacity	12
Methods	5	Room Demand	
Facility Selection	6	Overflow Beds	
Theoretical Framework	7	Operating Room Access	
Advisory Board Meetings	8	Facility Size	
Design Data Collection	9	Workload	23
		Distance between Patient Rooms	
		Distance from Workstations	
		Room Standardization	
		Motivation & Accountability	31
		Collaborative Spaces	
		Accessibility of Call Rooms	
		Staff Support	
		Contextual & Cultural Factors	39
		Accessibility of Labor Support Equipment	
		Prominence of Technology	
		Staff Access to Natural Views and Light	
		Patient-accessible Circulation	
		<hr/>	
		Conclusion	48
		<hr/>	
		Appendix	50
		Advisory Board	
		References	
		Glossary	
		Facility Profiles	

Executive Summary

Evidence-based design of the built environment may provide an underutilized platform for creating scalable improvements in healthcare.

Because walls are expensive to erect, floorplates of healthcare facilities do not usually change much in the near term. However, the functions of rooms and other spaces within the building may actually change frequently--as often as every two to three years in many hospital service units. This is understandable: as health systems evolve, clinical environments have shifting needs. But even when changes are anticipated, contingency planning is seldom informed by consistent measurement and feedback. As a result, healthcare designs are rarely informed by empirical evidence of what does and does not work. The consequences of a limited evidence-base includes propagation of designs that are low value, expensive, and even potentially harmful to patients.

Childbirth services provide an ideal test case to examine the role of the built environment on the value of healthcare delivery. Women who present to childbirth facilities for labor and delivery receive a discrete and well-defined episode of care. At the same time, this care is delivered in an environment that may need to accommodate a wide range of needs--from healthy patients who simply need to be supported through a natural process of labor to acutely ill patients who may need emergency surgery. As it turns out, the frequency of surgical birth (measured in terms of the cesarean delivery rate) provides a compelling proxy of healthcare value. Cesarean rates vary from 7% of all patients to 70% of all patients across American hospitals. Approximately half of these surgeries appear to be unnecessary in hindsight, with significant negative impact on the safety, affordability, and experience of care. The cumulative toll may be tens of thousands of major

surgical complications, hundreds of thousands of cases of avoidable suffering, and \$5 billion in wasted spending in the United States each year.

Given this consequential facility-level variation, we conducted a one-year exploratory study to better understand the opportunity to link facility design and cesarean rates. In this report we summarize four key contributions:

1. We convened experts to identify and validate a set of design elements that may impact care cesarean delivery rates.
2. We created a scalable methodology for collecting quantitative and qualitative design data.
3. We took detailed measurements of variation in design among twelve diverse facilities.
4. We generated more specific and testable hypotheses of how design may impact cesarean delivery rates

Collectively, these contributions provide a compelling basis to test these hypotheses in a wider cohort of facilities. Our findings also provide a basis for deeper exploration of the opportunities for evidence-based design to improve healthcare delivery more generally.

Background

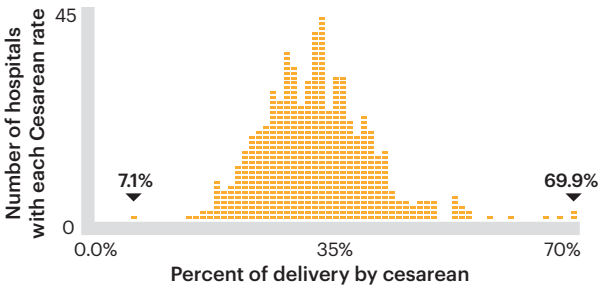
In the United States, the greatest predictor of whether a woman will have a cesarean delivery is not her personal risks or preferences, but instead the facility where she gives birth.^{1,2} Cesarean delivery rates vary tenfold at the hospital-level from 7% to 70%.³ When used appropriately, cesarean deliveries can be lifesaving; however, in the United States, one third of babies are born by cesarean deliveries and up to 45% of these surgeries may be avoidable.^{4,5} These avoidable surgeries can lead to unnecessary harm to mothers and newborns, including increased risk of hemorrhage, major infection, and severe complications in future pregnancies and \$5 million in additional health system costs annually relative to vaginal deliveries.^{6,7}

Across the United States, the design of childbirth facilities also varies dramatically. In 2012 in the United States, 98% of women delivered in a hospital, 0.6% of women delivered in a freestanding birth center, and 1.4% of women delivered at home or in another location.⁸ Childbirth facilities are often intentionally designed to provide different types of care along a spectrum of patient risk. Freestanding birth centers do not intend to provide surgical intervention whereas labor and delivery units retain advanced monitoring and surgical intervention capabilities. In addition to being designed for different types of care, childbirth facilities also differ substantially in the context of care, including geographic location, urban/rural settings, patient populations, and access to other ancillary medical services and non-medical amenities. While 15% of women deliver in hospitals with 2,500-17,000 births per year, 30% of women deliver in hospitals with less than 1,400 births per year and 8% deliver in hospitals with less than 100 births per year.⁹

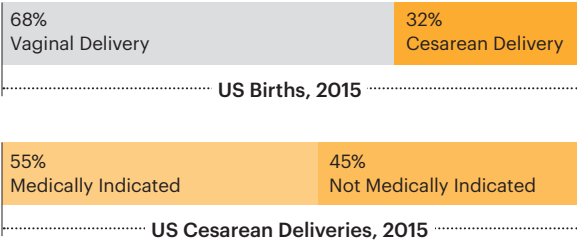
Within the diversity of care settings, prior research has established significant associations between hospital

design and both care processes and outcomes across several health care domains. In a review of over 600 studies, hospital design appears to impact patient safety, patient satisfaction, staff effectiveness, and overall care quality.¹⁰ Hospital design also appears to affect healthcare at distinct scales: the scale of the patient room appears to primarily influence patient safety and satisfaction, while the scale of the service unit primarily influences staff effectiveness and efficiency.^{10,11}

As prior research in obstetrical spaces has focused primarily on investigating the impact of design at the room scale on patient experience and satisfaction, there has been minimal attention to the impact of design at the labor and delivery unit or birth center scale on clinicians and clinical processes of care.^{12,13,14} Nonetheless, the unit scale appears to provide a compelling opportunity to understand the link between design and care in other domains. Optimizing pediatric ambulatory surgery center design to improve patient flow resulted in decreased non-operative time in the operating rooms by 50%, surgical procedure time by 26-43%, and post-anesthesia care unit time by 38-68% depending on the procedure.¹⁵



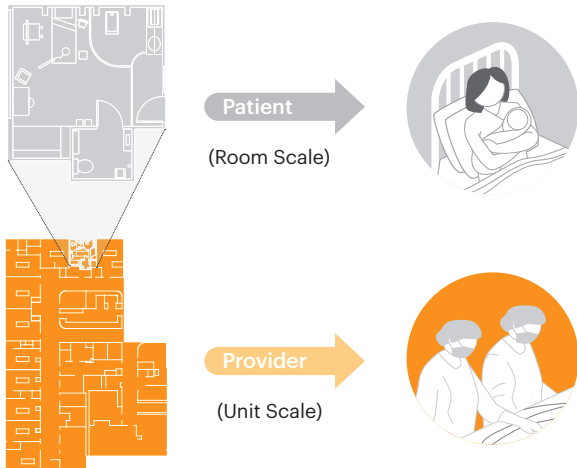
Cesarean rates vary widely between U.S. hospital facilities. This variation cannot be explained by clinical comorbidities or maternal sociodemographics. Data source: Kozhimannil, Law & Virnig (2013)



Above Data source: “Births: Preliminary Data for 2015.” National Vital Statistics Report. Centers for Disease Control and Prevention., Witt et al., 2014.

Right

Existing studies predominantly look at patient experience at the room scale. Our study focuses on provider processes of care occurring at the scale of the unit.



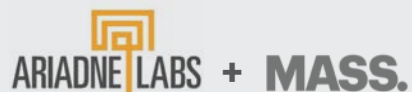
Methods

We conducted a mixed-methods, descriptive analysis of the design of 12 diverse childbirth facilities across the United States, including both hospital-based labor and delivery units and freestanding birth centers. Facilities were identified using an open online solicitation process and selected by the project team to maximize cohort diversity (detailed in the following pages). The design elements measured in this study, such as key distances and allocations of space, were identified based on literature review using a theoretical framework established by prior Ariadne Labs and MASS Design Group research. These elements were further refined with guidance from an expert advisory board.

The project team requested annotated floorplans from each selected facility. Floorplans were redrawn as needed using computer-aided design software in order to identify and count rooms by type and measure key distances and spaces. Both the purpose and use of spaces were confirmed by site visits or phone interviews with facility managers. Our advisory board added additional perspective in interpreting these findings to generate specific hypotheses of how design may support or hinder processes of care. The project posed no risk to patients and was exempted from review by the Harvard institutional Review Board.

Evidence-Based Design & Health Systems Research Collaboration

In 2014, Michael Murphy, the co-founder and Executive Director of MASS Design Group, presented research on the history of hospital design at Ariadne Labs, a joint center for health systems innovation between Brigham and Women's Hospital and the Harvard T.H. Chan School of Public Health. The historical and current design challenges he described resonated with the experiences of Dr. Neel Shah as a practicing obstetrician and a researcher interested in the way the clinical environment impacts care decisions. His team at Ariadne Labs was focused on differences in the management of hospital labor and delivery units, and realized many of the management practices they were studying were either supported or hindered by the physical design of the units. The combination of MASS Design Group's methodology expertise in analyzing design spaces and Ariadne Labs' content expertise in obstetrics health systems created an ideal partnership to investigate the impact of childbirth facility design on childbirth care.



Facility Selection

We intentionally selected twelve diverse childbirth facilities to capture a wide scope of facility types, scales, and contexts. Birth centers represented facilities designed to offer the lower treatment intensity for the lowest risk patients, while hospitals with high annual delivery volumes and high cesarean rates were assumed to offer higher treatment intensity to a broad range of patients.

To identify candidate facilities, we posted an online survey on the Ariadne Labs website (www.ariadnelabs.org) that was promoted via social media from December 2015 - January 2016. The three-part survey aimed to capture patients' perspectives on the impact of facility design on their experience of care, clinician or hospital managers' perspectives on the impact of facility design on their provision of care, and architects' perspectives on the key elements of childbirth facilities they had previously designed. We received 63 responses referencing facilities with significant design strengths or weaknesses for further analysis in our study. We also considered facilities involved in previous Ariadne Labs research for inclusion. The study ultimately included three birth centers and nine hospitals to optimize diversity with regard to facility type, location, delivery volume, cesarean rate and provider mix.

Birth Center	Birth Center	Hospital	Hospital	Hospital	Hospital
Freestanding facility	On hospital campus	Low cesarean rate, low delivery vol.	Low cesarean rate, high delivery vol.	High cesarean rate, low delivery vol.	High cesarean rate, high delivery vol.
<p>Above Characteristics of the desired facility study set</p> <p>Below Characteristics of facilities selected for inclusion in study</p>					
Facility Name	Facility Type	Location	Annual Delivery Volume	Primary Low-risk Cesarean Rate	Provider Mix
Baby & Company	Freestanding Birth Center	Nashville, TN	300	5.10%	Midwives
Minnesota Birth Center	Freestanding Birth Center	Minneapolis, MN	176	6.00%	Midwives
Dar a Luz Birth & Health Center	Freestanding Birth Center	Albuquerque, NM	200	10.0%	Midwives
Merit Health Natchez	Community Hospital Unit	Natchez, MS	888	15.0%	Obstetricians
The Mother Baby Center	Community Hospital Unit	Minneapolis, MN	5,400	15.4%	Obstetricians
Tuba City Regional Health Care Corporation	Indian Health Services Hospital/Navajo Nation Hospital Unit	Tuba City, AZ	500	18.0%	Obstetricians, Midwives
Beth Israel Deaconess Medical Center	Academic Hospital Unit	Boston, MA	4,700	20.9%	Obstetricians, Residents
Providence Portland Medical Center	Community Hospital Unit	Portland, OR	2,471	22.0%	Obstetricians, Midwives, Family Practice Physicians, Residents
Sharp Mary Birch Hospital for Women & Newborns	Women's Hospital Unit	San Diego, CA	9,100	25.8%	Obstetricians
Women's Hospital	Academic Women's Hospital Unit	Baton Rouge, LA	8,574	28.0%	Obstetricians, Residents
University of Chicago Medical Center	Academic Hospital Unit	Chicago, IL	2,100	32.4%	Obstetricians, Residents
University Medical Center of Princeton at Plainsboro	Community Hospital	Princeton, NJ	2,000	34.9%	Obstetricians

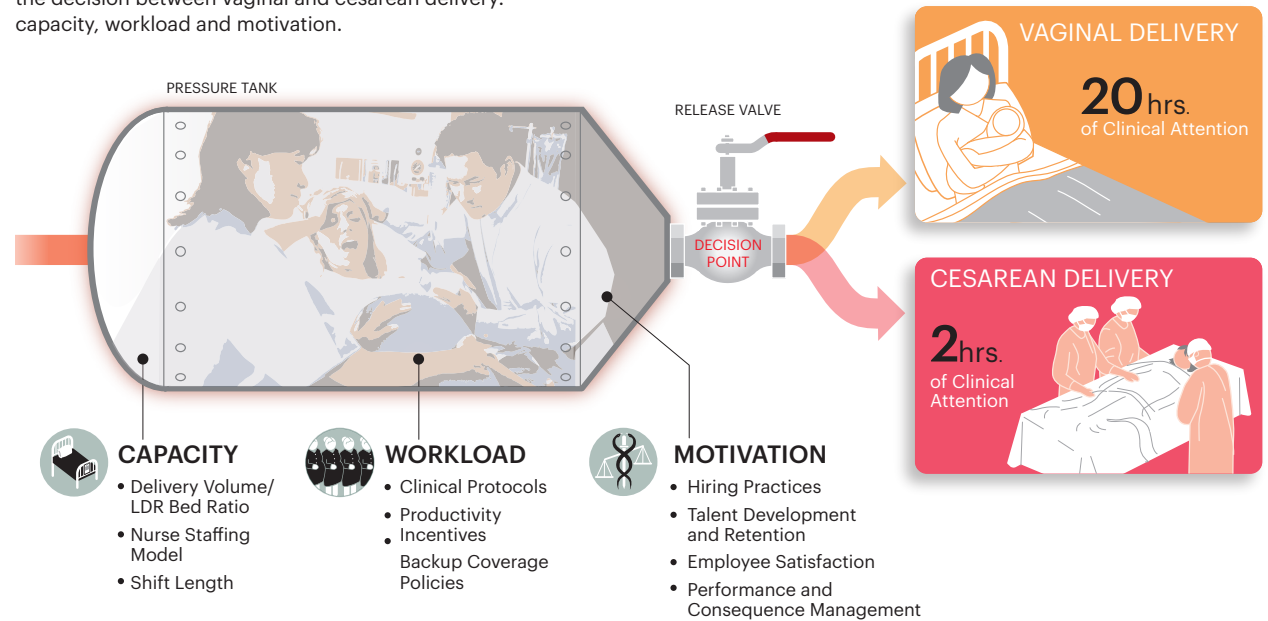
Theoretical Framework

Through prior work at Ariadne Labs, aimed at understanding the impact of management on care processes in childbirth, we had developed the “Pressure Tank Model” to explain the how the environment a clinician is working in may influence the decision to perform a cesarean delivery. In the Pressure Tank Model, limited resources, high workload, or limited motivation and accountability increase the pressure on clinicians to accelerate patient flow, which may lead to cesarean deliveries in clinically marginal cases.

In partnership with MASS Design Group, the Ariadne Labs team utilized the three dimensions of the Pressure Tank Model to identify evidence-supported design elements that may impact processes and outcomes of childbirth care. We supplemented our prior understanding of the design elements associated with each of these three dimensions with a literature review that focused on the impact of design on health care in childbirth as well as other time-critical, safety-critical domains, such as intensive care and critical care units.

Pressure Tank Model

In the Ariadne team’s original Pressure Tank Model, developed in prior work on management of care processes in childbirth, three system factors influence the decision between vaginal and cesarean delivery: capacity, workload and motivation.



Dimension	Design Definition	Examples of Design Elements from Prior Literature
Resource Capacity	Design elements that impact the ability of a facility to accommodate unexpected surges in patient volume or acuity	<ul style="list-style-type: none"> • Adaptability, convertibility, and expandability of spaces¹⁶ • Acuity-adaptable rooms¹⁷ • Single-bed rooms¹⁰
Workload	Design elements that impact the effort required by clinicians to deliver childbirth care	<ul style="list-style-type: none"> • Standardization of equipment locations, supplies, and room layouts^{18,19} • Unit layout^{20,21} • Relative locations of workspaces and functional areas^{21,22}
Motivation & Accountability	Design elements that impact the willingness of clinicians to expend effort	<ul style="list-style-type: none"> • Location and structure of workstations^{23,24} • Interdisciplinary spaces^{23,25} • Availability of communication tools²⁵ • Visual “symbolism” of responsibilities²⁵

Advisory Board Meetings

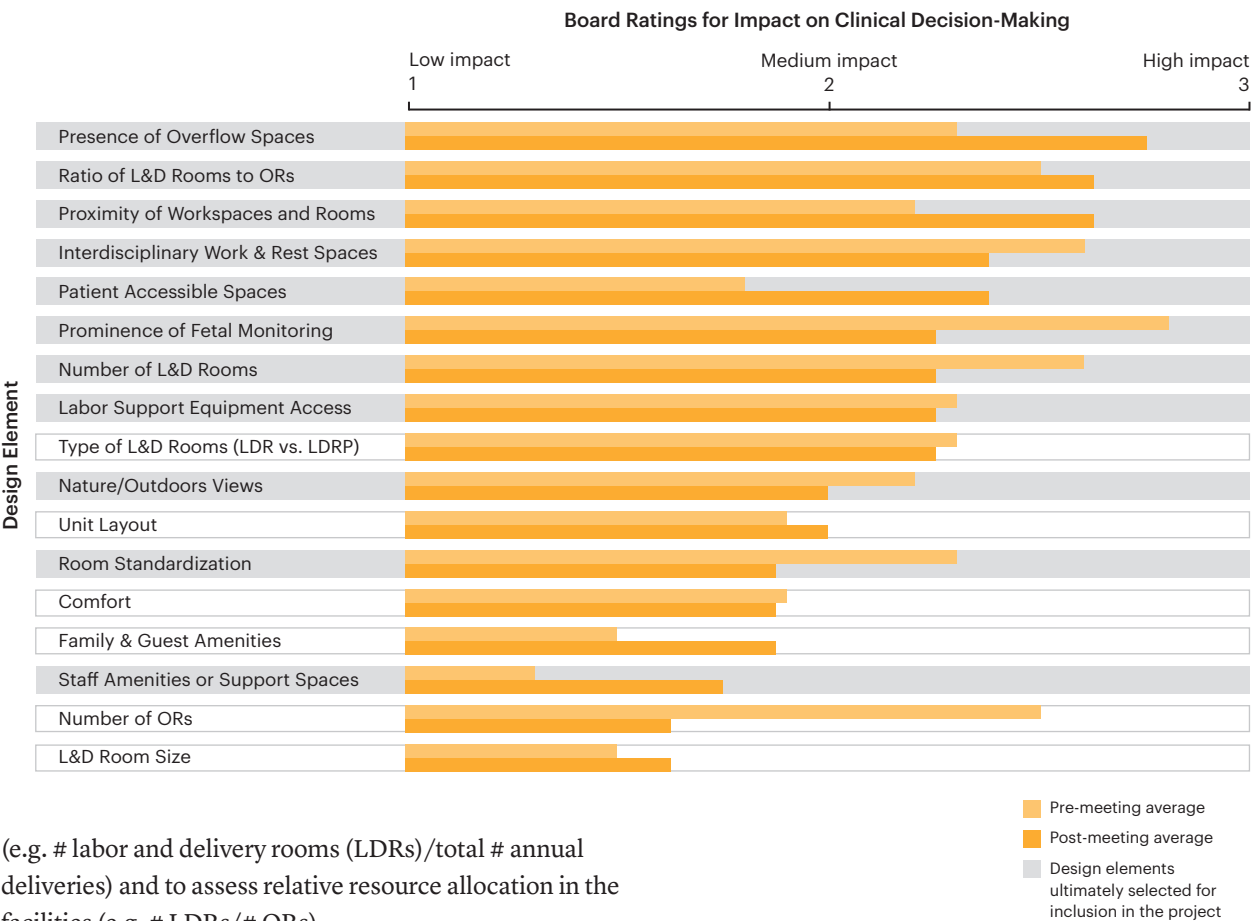
Expert Advisory Board

We convened a 10-member expert advisory board at two in-person meetings to guide the selection of the highest-yield design elements and to advise on the theoretical development of the project. The experts included key stakeholders and thought leaders in clinical obstetrics (obstetricians, nurses, and midwives), patient advocacy, facility management, health services research, architecture and evidence-based design (see Appendix for full list of advisory board members).

Modified-Delphi Process

We used a modified-Delphi consensus management process with the board to prioritize among the design elements identified through our prior research and the literature. Before meeting in person, board members completed a survey rating the relative impact of design elements on clinical decision-making during childbirth care and shared their hypotheses on the mechanisms behind these links based on their experiences. We presented the survey results to the board members at an in-person meeting and then conducted a moderated discussion to explore areas of disagreement. Following the meeting, the board members repeated the survey incorporating new perspectives raised by the interdisciplinary discussion of their responses.

The study team synthesized results from the two survey rounds and the meeting discussion to select the final list of design elements to measure and analyze across our twelve facilities. Based on the feedback from the board, we emphasized design elements where the group had clear hypotheses about the link between design and clinician decision-making about treatment intensity and selected ratios as metrics for many of these design elements to standardize for varying facility volumes



(e.g. # labor and delivery rooms (LDRs)/total # annual deliveries) and to assess relative resource allocation in the facilities (e.g. # LDRs/# ORs).

Several cross-cutting themes related to multiple design elements emerged from the meeting discussion. Specifically advisory board members commented on 1) the importance of considering the **flexibility/adaptability** of spaces (particularly with regard to accommodating unexpected surges in patient volume of acuity), 2) the role of **cognitive anchoring** in designating functional uses of spaces (for example, intentionally placing “sicker” patients in rooms closer to the operating suite), and 3) the role of design in facilitating or hindering **knowledge sharing** (for example ensuring there are adequate spaces for collaboration or interdisciplinary communication). These themes were used to interpret our exploratory findings and generate testable hypotheses.

Above

Advisory board members ranked design elements on a three-point scale from low impact on clinical decision-making (1) to high impact (3). Results include 8 survey responses pre-meeting and 10 responses post-meeting; gray boxes represent design elements that were ultimately selected for inclusion in the project based on the results of both the pre and post-meeting surveys.

Design Data Collection

Floor Plan Analysis

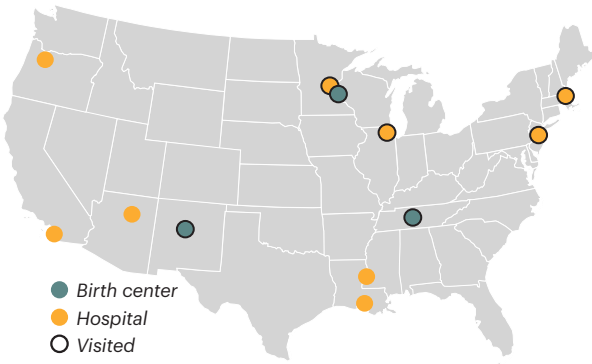
MASS Design Group created a two-page printed guide to assist facilities in submitting usable floor plans to the research team for analysis. We designed the detailed instructions to be understood by a health professional without design or architecture expertise. Instructions included advice about who to contact for the required documents (usually the facility manager), the necessary document format, and a list of annotations needed to allow the team architects to standardize and analyze the floor plans. Team architects then traced submitted floor plans using architectural drawing software to equalize measures for comparison across facilities and measured areas (square feet), distances (feet) and units (number) using built-in computer-aided design (CAD) software tools.

Site Visits

Following the initial analysis of facility floor plans, members of the study team conducted site visits at six of the recruited facilities to 1) confirm details of the facility floor plan not clearly labeled or not well understood, 2) understand how the design of the unit may help or hinder staff in their work processes, and 3) broadly characterize the social, economic, and medical context in which the facility operates. We selected the six facilities based on geographic location and design characteristics that would be valuable to document in-situ, including Dar a Luz Birth & Health Center (Albuquerque, NM), The Mother Baby Center (Minneapolis, MN), The Minnesota Birth Center (Minneapolis, MN), Baby + Co. (Nashville, TN), University of Chicago Medical Center (Chicago, IL), and University Medical Center of Princeton at Plainsboro (Plainsboro, NJ).

During each visit, the members of the research team met

with representatives from the facility, including clinical directors, nurse managers, and operations managers. The research team designed a structured site visit guide to provide a standardized organization to each visit and ensure all research questions were discussed with each facility team. Each site visit lasted approximately three hours including an introductory conversation to understand the history of the building and facility, a facility tour following the patient pathway through the unit or birth center, and a debrief of the tour to understand the way different observed design features impact the provision of care. During the tour, an architect member of the research team photographed key areas and updated annotations to the floor plans. The team also audio recorded the full visits for subsequent thematic analysis.



Above
Geographic distribution of facilities selected for site visits and phone interviews

Below
Floor plan submission instructions provided to facilities


Plan Submission Instructions

Thank you for participating in this study and providing us with plans of your birthing facility. Your contribution will be most helpful to our research analysis if you follow the guidelines below. Please email Deb Rosenberg at design@ariadnelabs.org or call 401-441-7655 if you have any questions about these instructions.

Part 1

OBTAIN TECHNICAL DRAWINGS OF EITHER YOUR UNIT OR BIRTH CENTER.

To send drawings to our team, please attach the files to an email with your facility name in the subject line and send to design@ariadnelabs.org



Above: Example floor plan of L+D unit or birth center.

- Usually the Facilities Manager at your institution will have these documents
- If possible, the drawings should be in a digital file format. Our preference would be .dwg or .dxf files, but .pdf files are also fine
- Please also check that the drawing has a scale, either as a graphic reference or as an annotated note (for example, 1/8" = 1'-0")
- The drawing should indicate basic furniture, door swings, and adjacent units or departments if applicable
- If multiple drawing versions are available, please send the most recent and detailed plans


Plan Submission Instructions

Part 2

PRINT PLAN AND OVERLAY NOTES ON SPACE USES

Because floorplans don't always reveal the specific uses that might occur in an area or reflect changes over time, please print the floorplans and overlay notes on different areas referring to the suggested list below. It's okay for this to be messy and handwritten.

Once you're done please scan or take a photo of the annotated floorplan drawing, and email it to design@ariadnelabs.org with your facility name in the subject.



Left: Example of annotated floorplan, with clinical, staff and other areas noted

CLINICAL

1. L + D rooms (and indicate LDR or LDRP)
2. OR(s)
3. Nursing station(s)
4. MD/CNM work station(s) if different
5. Triage
6. Antenatal monitoring/testing
7. Post-anesthesia recovery areas
8. Overflow rooms/areas (if applicable)
9. EFM Monitoring areas (monitor locations)
10. Medication room(s)
11. Utility areas
12. Direction of related units (NICU, Postpartum, Triage - if not on unit)

Please note all applicable areas to the right and add additional areas as required. Your facility may not include all of these areas.

STAFF

13. Staff lounge
14. Staff offices
15. Staff restrooms
16. Locker rooms
17. Call rooms

OTHER

18. Patient public restrooms
19. Waiting areas
20. Nutrition areas (snacks, ice, etc.)
21. Other (please specify)
22. Related Room (NICU, Postpartum, Triage if off-floor)

Phone Interviews

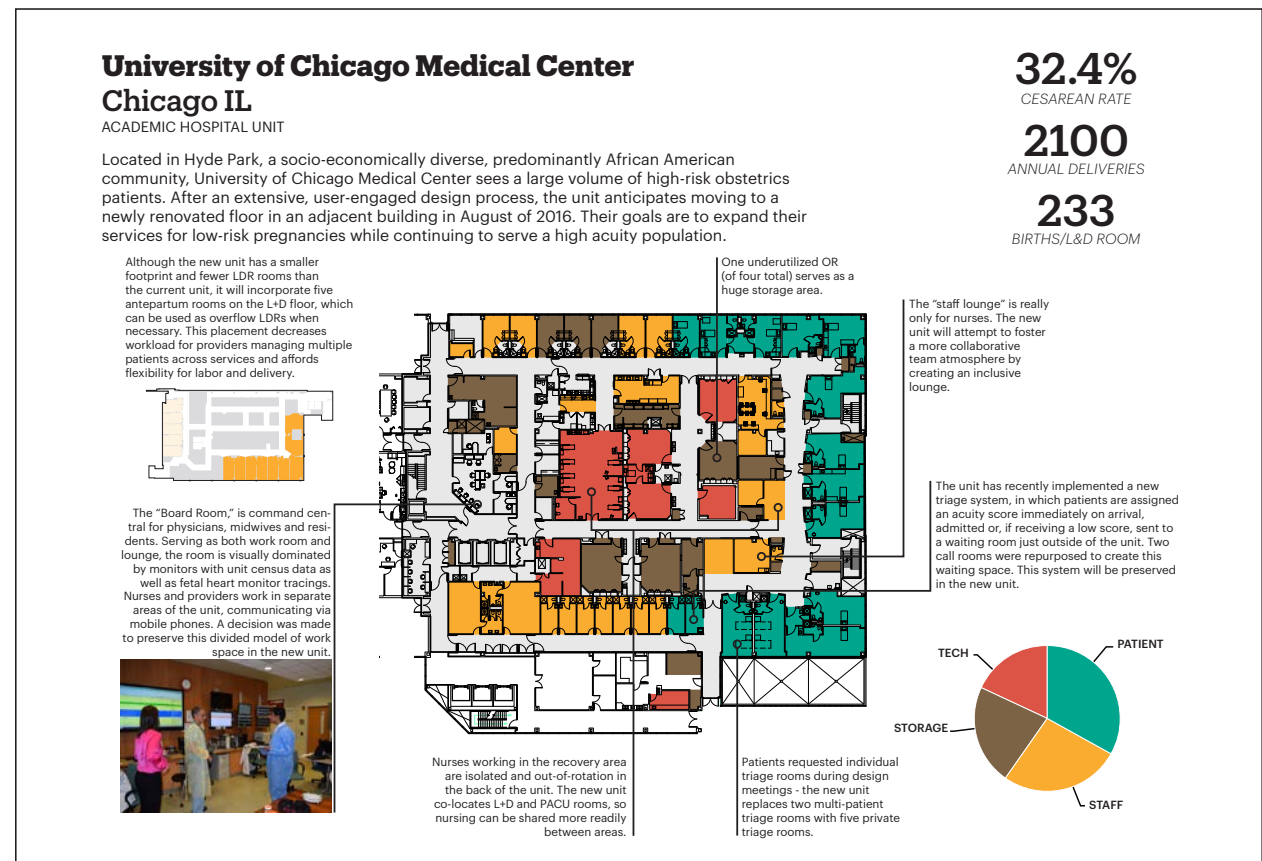
We noted the most important findings that were identified during the site visits and had not been captured through the floor plans, including descriptive details about how specific design elements impacted care. Based on these findings, we adapted the site visit guide for phone interviews and condensed the guide to cover the highest-yield information in an approximately one-hour time frame. A member of the research team with expertise in both nursing and design conducted in-depth phone interviews with nurse managers and facilities managers from the remaining six facilities between August-October 2016, including Sharp Mary Birch Hospital for Women & Newborns Hospital (San Diego, CA), Providence Portland Medical Center (Portland, OR), Merit Health Natchez Hospital (Natchez, MS), Tuba City Regional Health Care (Tuba City, AZ), Beth Israel Deaconess Medical Center (Boston, MA) and Woman's Hospital (Baton Rouge, LA). Prior to the interview, interviewees were emailed a simplified floor plan of their facility for reference and to help guide the discussion. The interviewer recorded the phone calls and took notes to use in our analysis. Similar to the site visits, information from the phone interviews augmented the data accessed from the floor plan analysis and enhanced our understanding of relevant themes and hypotheses about the way design impacts care.

Facility Profiles

We created a collection of data-rich profiles for the twelve facilities included in our study. The profiles included summary information and basic statistics about the facility (cesarean rate, annual delivery volume and a ratio of deliveries to number of LDRs), the facility floor plan, and key design themes extracted from the facility site visit or phone interview. We color-coded the facility floor plan to highlight the relative proportion of patient, staff, technical, and storage spaces. These proportions are also represented in the pie chart.

Below

Example Facility Profile. The complete set of facility profiles can be found in the Appendix.



Introduction to Results

Measured Variation in Facility Design

We found wide variation in design of U.S. childbirth facilities and developed hypotheses about which aspects of this variation may hinder or support intended patient care functions. A number of key differences between facilities are readily seen at the scale of the facility floor plan: the overall size and shape of the unit; whether the unit is contained on a single floor or is spread across multiple wings or levels of a larger building complex; and whether nursing stations are located centrally or are distributed throughout the unit. Other metrics required a systematic method of transforming design elements into quantitative metrics to identify variation between facilities: the distance a nurse must travel between labor and delivery rooms (LDRs), the ratio of collaborative staff spaces to total staff spaces, and the percent of circulation (area used for moving from one area to another, like a corridor) accessible to laboring patients. As described above, we organized these metrics around the capacity, workload and motivation framework. In addition, several design elements relating to cultural/contextual factors emerged as important, but difficult to measure quantitatively.

Capacity

Design elements that impact the availability of a facility to accommodate unexpected surges in patient volume or acuity.

- > **Room Demand:** annual deliveries per labor and delivery room
- > **Overflow Beds:** ratio of overflow beds to LDRs
- > **OR Access:** ratio of ORs to LDRs
- > **Facility Size:** ratio of annual delivery volume to total unit area

Workload

Design elements that impact the effort required by clinicians to deliver childbirth care.

- > **Distance between Patient Rooms:** maximum distance between LDRs
- > **Distance from Workstation to Patient Rooms:** average distance from nurse station to labor and delivery room
- > **Room Standardization:** degree of standardization of LDR room interiors

Motivation & Accountability

Design elements that impact the willingness of clinicians to expend effort to deliver childbirth care.

- > **Collaborative Spaces:** ratio of total staff area to collaborative staff spaces
- > **Accessibility of Call Rooms:** maximum distance from call room to labor and delivery room
- > **Staff Support:** ratio of total unit area to staff support area

Contextual & Cultural Factors

Design elements that may impact a number of other contextual and cultural factors that are not easily characterized with quantitative measurements.

- > **Accessibility of labor support equipment**
- > **Prominence of technology**
- > **Staff access to views and natural light**
- > **Patient accessible circulation**



Capacity

Capacity design elements theoretically impact the availability of space to perform the core functions of the facility. To better compare capacity across facilities, we calculated the metrics as ratios relative to the annual delivery volume or the number of labor and delivery rooms. We found that many childbirth facilities are challenged by limited physical space to house labor and delivery patients relative to the number of patients who deliver at the facility each year. The degree of this challenge differs by facility based on factors such as funding, whether the facility or unit is located in an intentionally built or retrofitted space, and how their delivery volume has changed since their most recent construction. Ultimately however, the more deliveries a facility performs with a fixed amount of space, the less time any given patient can spend at the facility in labor. Birth centers aim to optimize time at facility by admitting patients later in labor and discharging them sooner. Hospitals may optimize time in labor by either doing the same as the birth centers, or by delivering sooner via cesarean. The capacity design elements measured include: the ratio of total annual delivery volume to number of rooms available for labor (LDRs), the ratio of annual delivery volume to number of overflow beds, the ratio of ORs to LDRs and the ratio of total area of the unit/facility to annual delivery volume.

Previous page

Multi-bay obstetric triage area at Beth Israel Deaconness Medical Center sometimes serves as an overflow area when the unit is over capacity

Design Elements

Room Demand
(Annual delivery volume per LDR)

Overflow Beds
(Ratio of overflow beds to LDRs)

Operating Room Access
(Ratio of ORs to LDRs)

Facility Size
Ratio of annual delivery volume to total area of unit (deliveries/sq. ft)

Hypotheses

Higher deliveries/room/year increases the pressure to move patients expediently through labor to delivery, driving up treatment intensity.

Higher ratio of overflow beds to LDRs increases ability to accommodate unexpected surges in patient volume, lowering treatment intensity.

A higher ratio of ORs to labor and delivery rooms induces the demand for surgery on the unit and increases treatment intensity.

A higher ratio of annual delivery volume to total area of unit or facility decreases capacity per birth and increases treatment intensity.

Capacity

Room Demand

(Annual delivery volume per LDR)

Annual delivery volume refers to the number of patients delivering (vaginally or by cesarean delivery) at a given facility over the course of one year. Annual delivery volume was self-reported by study facilities. Annual delivery volume among our sample ranged from the smallest freestanding birth center seeing only 176 deliveries each year (Minnesota Birth Center) to the largest, specialty women's hospital delivering 9100 babies annually (Sharp Mary Birch Hospital for Women & Newborns).

The number of deliveries per labor and delivery room (LDR) per year at each facility varied widely, ranging from 75 to 100 deliveries per LDR per year at birth centers and 145 to 479 deliveries per LDR per year at hospitals. Stated another way: at Baby + Co., there is a delivery in each room every four days; while at Sharp Mary Birch, there is more than one delivery in each of their 24 rooms every single day.

We observed a positive relationship between higher ratios of annual deliveries per LDR and cesarean rates, indicating that demand for rooms may contribute to cesarean overuse. Conversations with facility managers and our advisory board further validated this hypothesis.

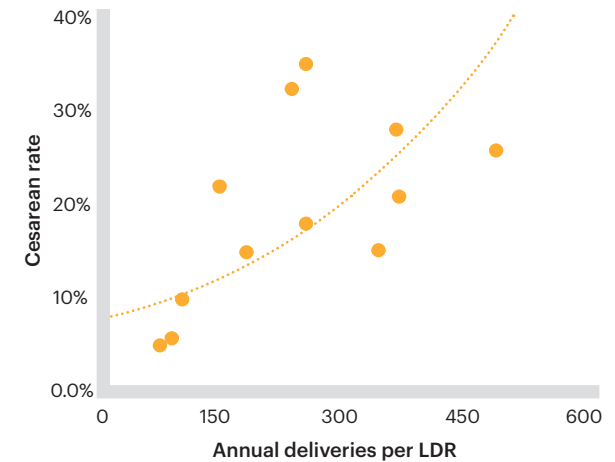
Currently, little guidance exists for facilities when budgeting number of LDRs. The Facilities Guidelines Institute (FGI) stipulates labor room size should be 340 square feet minimum of clear floor area (meaning unobstructed floor space that could accommodate a single, stationary wheelchair and occupant), but not number of labor + delivery rooms.²⁶ The U.S. Department of Defense issues very specific guidelines for design and

construction of obstetrics wards, with complex algorithms for determining the appropriate number of LDRs as a function of anticipated patient volume, average length of stay and occupancy rate, but these guidelines only apply to military hospitals.²⁷ Many individual design firms will also have their own algorithms for determining the appropriate number of rooms per volume, but one of our advisory board members noted that often civilian hospitals will opt to build fewer LDRs than needed for the volume because of physical or financial limitations.

Birth centers cited the threshold of around 100 deliveries per room per year as a common “rule of thumb” for maintaining the midwifery model of care, which emphasizes individualized and bedside support for laboring women. The American Association of Birth Centers has published national standards for the safe and high-quality management and operations unique to U.S. birth centers, but does not specify labor and delivery room size or number.²⁸

Even facilities with recent renovations or entirely new unit designs frequently lacked sufficient LDRs to accommodate surges in patient volume. At The Mother Baby Center, annual delivery volume increased unexpectedly after the construction of their new unit. Almost immediately upon moving in, staff asked the facilities manager to convert two antepartum rooms to LDRs to deal with the shortcoming.

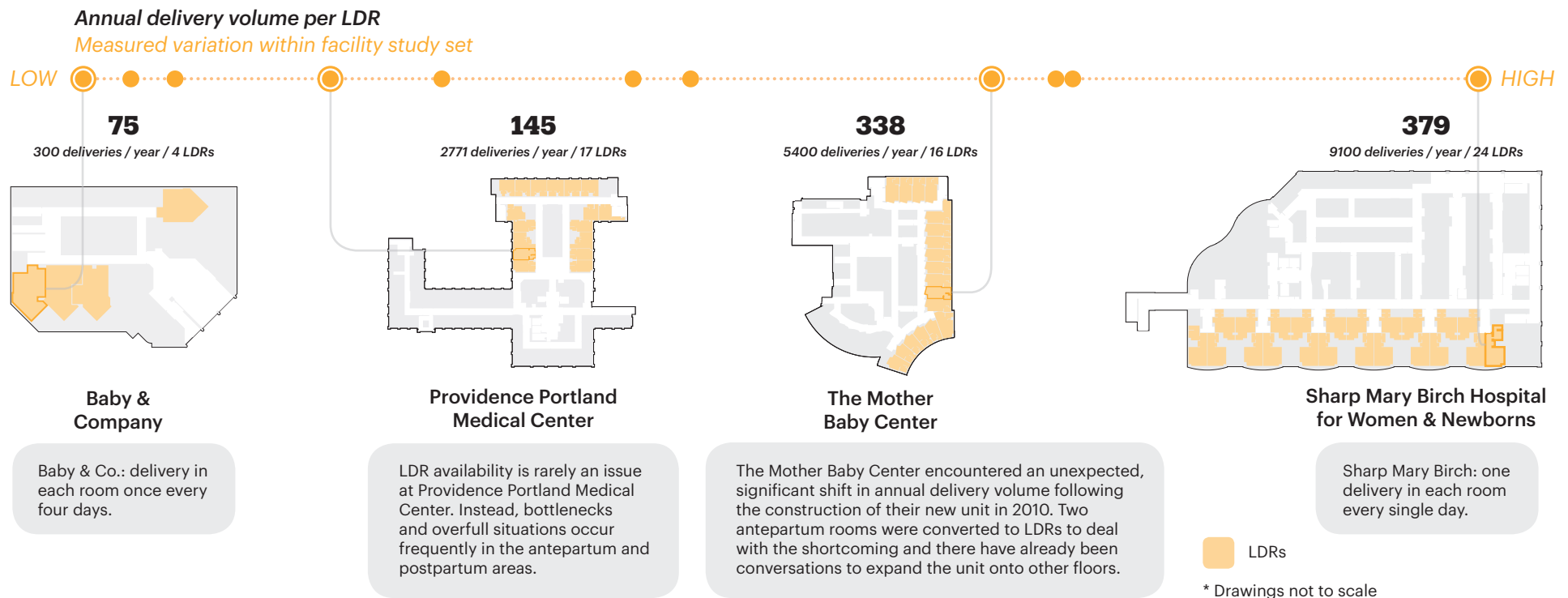
Difficulties anticipating baseline shifts in delivery volume account for one part of the capacity challenge, but daily unit census also fluctuates unpredictably from completely filled to capacity to nearly empty. As one nurse-manager at University Medical Center of Princeton at Plainsboro explained:



“The most we’ve done is 19 [deliveries] in 24 hours, and every week we’ll see at least two to three days where we’ll hit double digits... And then there’s the Sunday where we only have one. And it just kills us.”

Basing LDR numbers on averages doesn’t address these extreme situations. “If your head is in the oven and your feet are in the fridge, then on average you should feel fine,” mused another nurse at University Medical Center of Princeton at Plainsboro -- but for staff struggling to adapt their space and their work to those extremes, this is clearly not the case.

The rate at which patients move through LDRs affects who prepares rooms and how they are prepared for the next patient as well, which in turn places limits on the model of care that is possible. At Dar a Luz Birth & Health Center (100 deliveries/room/year), midwives not only care for women in labor and delivery, they also scrub the birth tubs and hang the laundry between each patient. At higher turnover rates this would not be sustainable. At Beth Israel Deaconess Hospital (362 deliveries/room/year), when there is a patient surge, an urgent overhead code alerts housekeeping, in addition to the nurses and physicians. Such resources typically require economies of scale that larger facilities can provide.



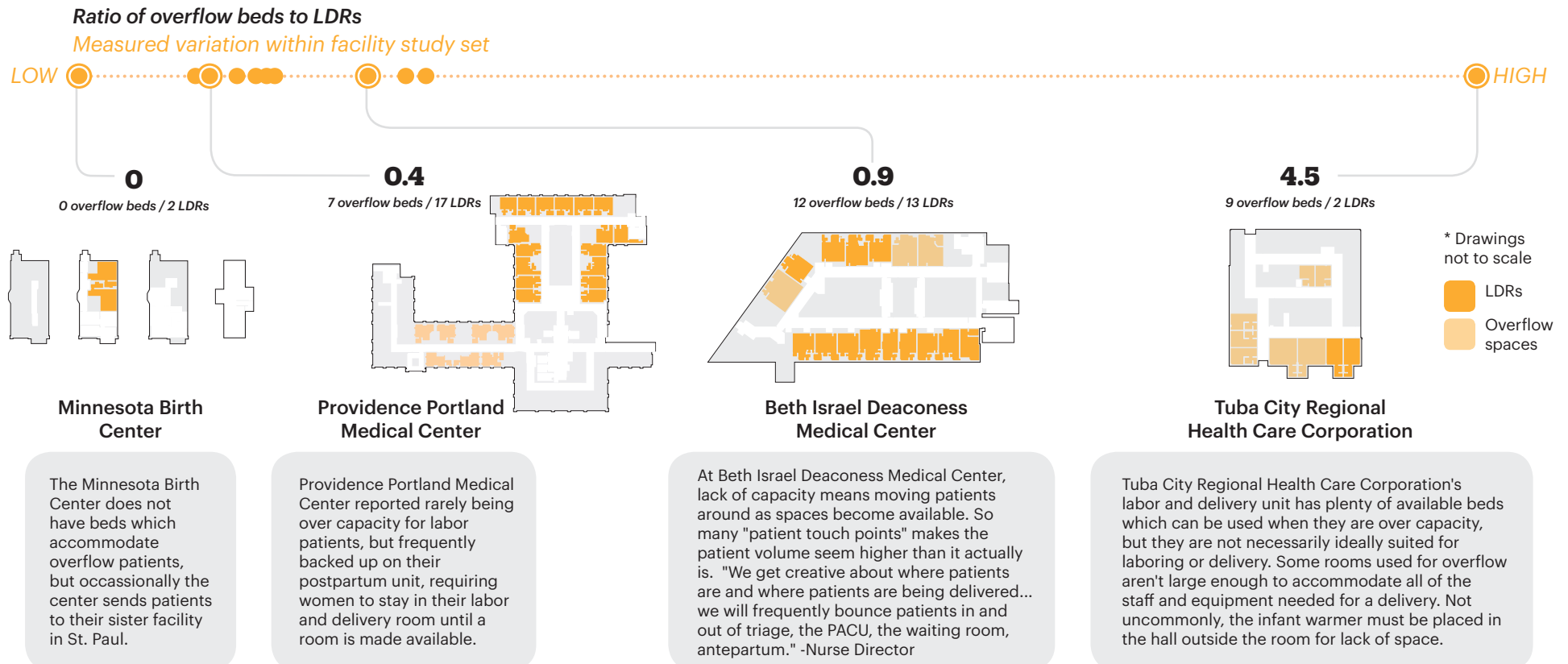
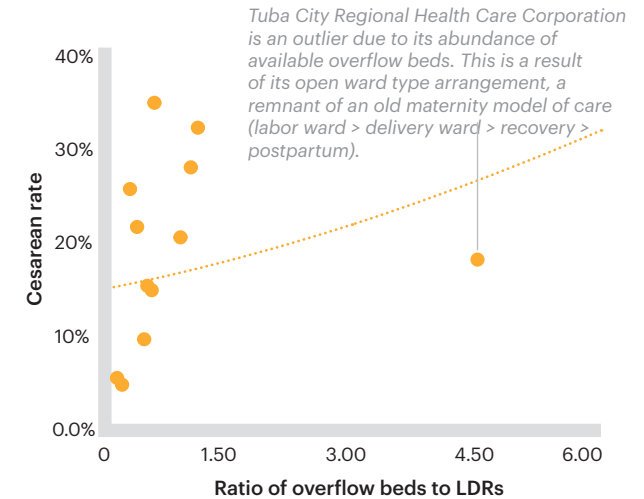
Capacity

Overflow Beds

(Ratio of overflow beds to LDRs)

Facilities reported a wide range of solutions to the challenge of accommodating surges in patient volume or acuity. Many facilities designate “overflow beds”, spaces that typically have other primary purposes, but can be used for labor and delivery in a pinch.²⁹ These beds were most commonly located in triage bays, antepartum rooms, and ORs. We assessed overflow capacity as a ratio of the number of overflow beds to the number of primary labor and delivery beds.

The total number of overflow beds ranged from 0 to 25 beds. When normalized in a ratio to the number of primary LDRs, the resulting ratio ranged from 0 (Minnesota Birth Center) to 4.5 (Tuba City Regional Health Care Corporation). We hypothesized that facilities with a lower ratio of overflow beds to LDRs may have decreased capacity to accommodate unanticipated increases in patient volume due to a low number of overflow beds relative to primary LDRs. However, the trend observed in our sample shows the opposite relationship. As discussed above, the ratio of annual deliveries to LDRs is not always reflective of actual delivery volume, so a lower ratio of overflow beds to



primary LDRs may indicate that the facility had sufficient primary LDR capacity for their delivery volume and does not need overflow spaces. For example, Providence Portland Medical Center reported rarely being over capacity for laboring patients, but instead frequently backed up on their postpartum unit. In this case, overflow space is not needed for labor and delivery, but instead primary LDRs are used as overflow space for postpartum. However, in a broader sample, we believe we would be unlikely to find a large number of facilities with excess labor and delivery capacity due to the budget constraints of this service line, so it is still important to consider the design of overflow spaces.

Even small birth centers in our sample with two or three LDRs considered contingencies for overflow situations. As one nurse-midwife at Baby + Co. pointed out, “[e]ven at 450 or 500 births, you’re really talking about one or two births a day, maybe, right? That’s not how it works. It’s like six at once and then none for three days. That’s why it’s important for the space to be flexible.” In the case of The Minnesota Birth Center, overflow capacity could be accommodated at a sister facility in nearby St. Paul -- and vice versa --when needed.

The availability and the use of overflow beds is limited by a number of factors. First, the overall size of the unit or facility matters, but not as much as the adaptability of various room types to accommodate labor and delivery. When maternity related services (triage, antepartum, labor and delivery, postpartum) are located nearby labor and delivery they can be more readily utilized for overflow when needed. In the University of Chicago’s new unit plan, triage, pre-op, and PACU areas are co-located and designated as swing space, meaning they can house patients for any of the above services as needed. In other facilities (such as The Mother Baby Center and Beth

Israel Deaconess Medical Center), these clinical areas are located off the labor and delivery unit, making them less practical to use as overflow accommodation.

The size of overflow rooms also restricts their potential usability. As stated above, FGI guidelines restrict the minimum area allowed for rooms used for laboring and delivery (minimum 340 square feet clear floor area). Rooms which don’t meet the minimum area requirement aren’t technically permitted to serve in a labor and delivery capacity, and according to the University of Chicago, these space standards have critical implications.

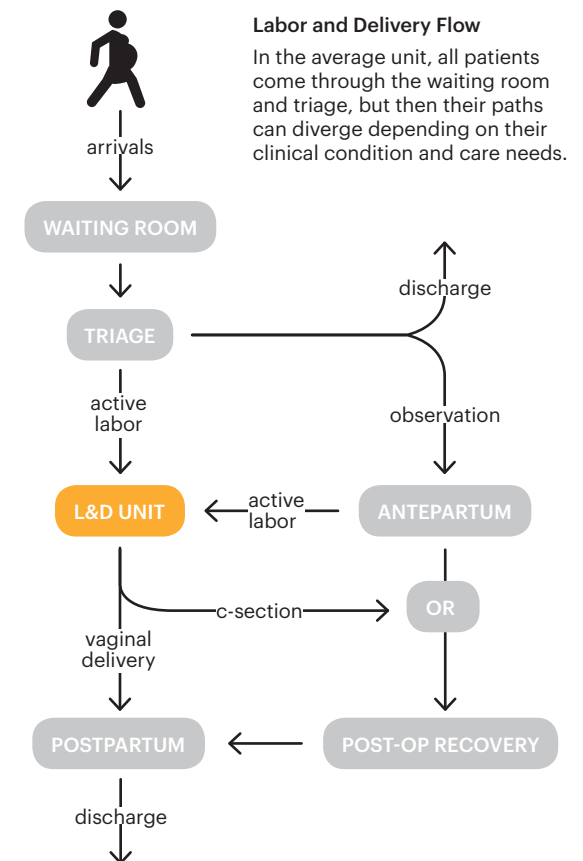
“We have some rooms we can utilize for observation, but they technically are too small to deliver in so, if the baby is precipitously delivering we’ll bring them in here [an OR] quickly. It also gives the NICU more space to resuscitate a baby. We’ve had a couple of 24-week precipitous deliveries in those rooms [triage beds] and it’s a disaster because the NICU can’t adequately get their equipment in those rooms.”

Shuffling patients around a unit also affects patient satisfaction with their birth experience. At Beth Israel Deaconess Medical Center, “We get creative about where patients are and where patients are being delivered...we will frequently bounce patients in and out of triage, PACU, waiting room, antepartum.” Similar maneuvering is done at University Medical Center of Princeton at Plainsboro:

“What we have been doing to deal with all of our surges, is moving our moms over from LDR to a couple of rooms in our postpartum unit next door to recover. They will go there until an actual postpartum room opens up...So what was two stops before, we have made it three stops. And so it’s a staffing nightmare—as I’m sure you can imagine, and housekeeping wants to kills us. ...and the patients aren’t thrilled....We have postponed our inductions...but there is no sending someone away. We have delivered in the OR, we set up our tub-room once...but didn’t end up

using it. It is really more of a notification system, for our OB’s notifying them that they need to get patients discharged and make space for more. Occasionally we will have to bring our recovering moms down into the pediatric unit—which is obviously not great either for patient satisfaction.”

Anticipating annual delivery volume to reduce reliance on overflow beds or purposefully designing overflow beds around the consideration of women and their families could mitigate the negative patient experiences associated with overfull facilities.



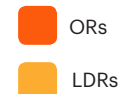
Capacity

Operating Room Access

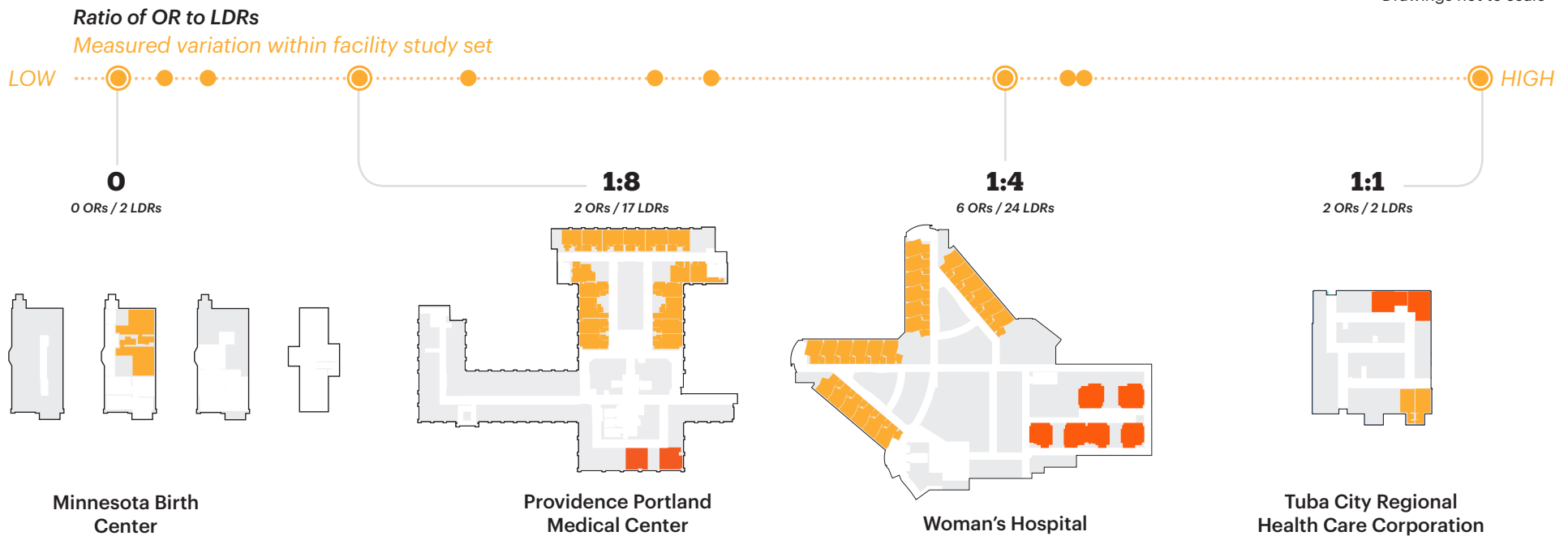
(Ratio of ORs to LDRs)

Operating room (OR) access is a critical component of capacity for performing both scheduled and emergent cesarean deliveries. Access is a function of the physical space (number and availability) as well as staff to provide anesthesia and perform the surgery. OR access was measured as a ratio of ORs to LDRs for each facility

to understand how the relative capacity of the unit to perform a cesarean delivery versus a vaginal delivery would impact treatment intensity. Based on insights from a facilities manager on our advisory board, we hypothesized that a higher ratio of ORs to LDRs may be associated with higher cesarean rates through a “supply-induced demand mechanism”: the more readily accessible the OR, the fewer barriers to performing surgery. Of note, freestanding birth centers do not contain



* Drawings not to scale



If a woman requires higher level care, including surgical intervention, during labor or delivery, she is transferred to The Mother Baby Center (across the street). A solid relationship between staff, as well as admitting privileges for Minnesota Birth Center midwives allows for smooth and easy transfers.

Providers at Providence Portland Medical Center confirmed that they feel a scarcity of ORs on their unit, requiring use of the hospital's main OR (which is located in an adjacent unit) as often as “a couple of times per month.”
-Director of Perinatal Services

Four of Woman's Hospital six ORs are dedicated for OB use. The unit also has access to two ORs which are shared with the adjacent GYN surgical unit. Their nurse-manager estimates they use those overflow ORs only two to four times per year.

Until 2005, the unit did not have a dedicated obstetrics OR. When the unit was renovated, a PACU and two ORs were converted from office and storage spaces. One OR belongs to Labor + Delivery; the other is technically for general surgery. “In eight years, we've only used both ORs for c-sections once or twice.”
-Acting Supervisor

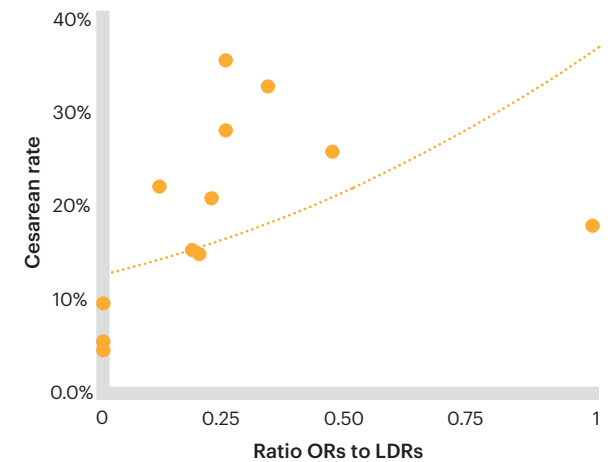
ORs - patients who require cesarean delivery must be transported to the nearest hospital.

Among our sample set, the absolute number of ORs on hospital labor and delivery units does not vary widely. Regardless of annual delivery volume, most units have two or three ORs. However, we found that the ratio of ORs to LDRs ranged from relative scarcity - 1:8 (1 OR for every 8 LDRs at Providence Portland Medical Center) to a relative abundance of ORs - 1:1 (1 OR for every 1 labor and delivery room - Tuba City Regional Healthcare Corporation).

Providers at Providence Portland Medical Center (1:8) confirmed that they feel a scarcity of ORs on their unit, requiring use of the hospital's main OR (located in an adjacent unit) as often as "a couple of times per month." In fact, they reported this capacity element was more critical for their unit than the number of LDRs. Both the University of Chicago and University Medical Center of Princeton at Plainsboro complained of OR bottlenecks as well, despite having proportionately more ORs (1:3 and 1:4).

The number of ORs on a labor and delivery unit depends on several factors. First, units serving higher acuity patient populations, which are more likely to need cesarean deliveries, require greater OR access. When the University of Chicago filed a certificate of need for their new unit design, they advocated at the state level to get approval for a second OR. They argued that despite their low annual delivery volume, they serve a high-risk population. Their current unit uses three ORs; even still they struggle with turnover. The scope of surgeries performed in the labor and delivery ORs also impacts the capacity needs. Units that also perform gynecological surgeries commonly have additional ORs dedicated to

these procedures. These additional ORs can flexibly accommodate cesarean deliveries if necessary, as at Sharp Mary Birch Hospital for Women & Newborns. Another factor in planning the number of ORs is proximity of the labor and delivery unit to the hospital's main surgical suites. When Merit Health Natchez merged with another community hospital and renovated their labor and delivery unit, they had a choice to build four LDRs and two ORs or five LDRs and only one OR. The CEO explained that they based their decision to build one OR on the adjacency of the main ORs, located directly below and easily accessible. Natchez is notably an outlier among our sample, with only a single OR dedicated to labor and delivery.



Capacity

Facility Size

(Ratio of annual delivery volume to total unit area)

The overall area of a facility may be thought of as an upstream measure affecting many other functional areas, including number of LDRs, amount of circulation, and capacity for staff support spaces. Tight units are forced to economize on space, generally favoring patient-facing clinical spaces over staff areas. We predicted that treatment intensity would increase with less physical space per annual delivery due to the decreased capacity per birth.

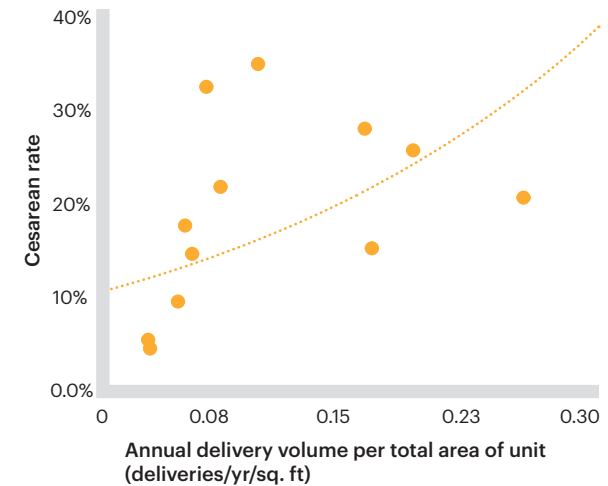
The ratio of annual deliveries per square feet of unit or facility range from large (1 delivery per 33 square feet at The Minnesota Birth Center) to much more constricted (1 delivery per 4 square feet). Interestingly, this metric appears to have a stronger relationship to annual delivery volume than facility type with hospitals with smaller annual delivery volumes aligning more closely with birth centers than higher volume hospitals in our study sample. Our analysis suggests the possibility of a positive relationship between ratio of annual deliveries per square feet and cesarean rates.

While increased facility size suggests increased capacity, a number of other factors impact the functionality of this space. When looking for a building to renovate for their Nashville birth center, Baby + Co. couldn't find the ideal size (5-6,000 SF) in the fast-developing real estate market. They purchased the current building (8,000 SF) out of necessity. "So, we have the big break room, bigger birth rooms - everything here is like Cadillac." But they do not plan to increase their delivery volume proportional to the greater area of their current space; their director explained, "[T]here is good data on how big is too big and it seems to be max 500 births per year, where you lose

intimacy and good outcomes." Their goal is to preserve an intimate experience of childbirth for that maximum annual delivery volume in spite of their excess facility area. On the flip side, one physician at The Mother Baby Center, which delivers 5400 babies annually in 33,007 square feet, complained that the patient experience has suffered from the size of their facility.

"I think it would be really cool as a mom to come into a unit and feel like it's a small place—but a small place nested in a tertiary, quaternary facility so if I, as a mother, get into trouble there is all this support that is there...Because that is feedback we get; that sometimes it feels like a baby factory, and so if there was a way—especially in high volume places—to make it feel less so...if we could take some of that bigness out of it, it would bring the birth-center experience into the hospital."

While many unit renovations deal with the physical constraints of a cramped hospital campus, new hospital projects can have the opportunity to intentionally size their departments. In these cases, unit size is based on anticipated volume, which translates to number of labor and delivery rooms; the rest of the unit follows. However, as discussed above (see discussion around annual deliveries/LDR), there are few reliable standards for calculating number of LDRs. We were interested to learn that for some obstetric staff, there may be a point of diminishing returns when it comes to overall size. To a point, size increases capacity - but comes at a cost of extended travel distances between patient rooms and team workstations that may contribute to treatment intensity; as well as contribute to a more intangible loss of intimacy that could impact patient experience.





Workload

Workload design elements theoretically impact the effort required by clinicians to care for patients. Travel distances required by staff can have a significant impact on the amount of effort required to perform work duties in a given shift. Based on the Pressure Tank Model, we hypothesize that facilities with design elements that increase staff workload may have higher treatment intensity. The workload design elements we measured included average distance from nurse station to labor and delivery room, maximum distance between LDRs, and standardization of LDRs.

Design Elements

- Distance between Patient Rooms*
(Maximum distance between LDRs)
- Distance from Workstations to Patient Rooms*
Average distance from nurse station to LDR
- Room Standardization*
Degree of standardization of LDR interiors

Hypotheses

- Increased distances between labor and delivery rooms increase staff workload and drives up treatment intensity.
- Increased distances from nurse station to labor and delivery room increase workload for staff and increase treatment intensity.
- Increased labor and delivery room standardization increases efficiency and decreases workload, lowering treatment intensity.

Previous page

Long corridors, like this one
University Medical Center
of Princeton at Plainsboro,
increase workload for staff

Workload

Distance between Patient Rooms (Maximum distance between LDRs)

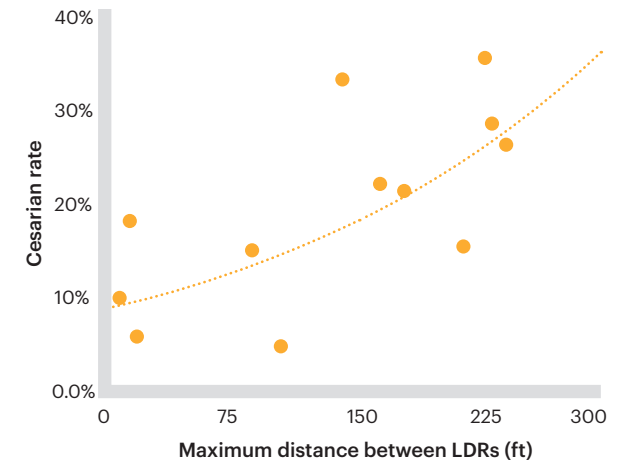
For staff caring for multiple patients in a single shift, distance between labor and delivery rooms (LDRs) can greatly impact workload. While AWHONN staffing guidelines³⁰ recommend nurses care for no more than one patient throughout much of labor, many facilities reported struggling to meet this benchmark; like obstetricians and midwives, nurses often have to manage multiple patients concurrently.

Closely-spaced, efficiently laid out units, like Tuba City Regional Health Care Corporation, contrast with sprawling units like University Medical Center of Princeton at Plainsboro, where nurses may find themselves literally running between rooms. During our site visit one obstetrician said he had invested in gels for his shoes after they moved to their new unit: “The path going from room to room to go to a supply room, it really kills our staffing”.

Maximum distance between LDRs varied from 9 to 242 feet (equivalent to rounding 3rd base in baseball). Among the hospital subset, maximum distance between LDRs was, on average, 164 feet. Tuba City Regional Health Care Corporation, with only two LDRs, was more similar to the birth centers (18 feet), while Baby + Co., with three large LDRP suites and a floor plan larger than the typical birth center, measured closer to the range of hospitals (106 feet).

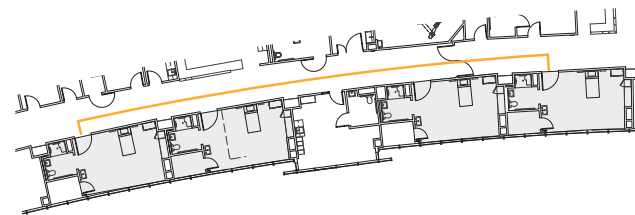
Factors affecting the distance between LDRs include not only the overall size and layout of the unit but, as staff at UMC Princeton at Plainsboro pointed out, also the size of individual LDRs. As LDRs increase in square footage, the distance between adjacent rooms necessarily increases

as well. Facility Guidelines Institute (FGI) require almost three times the area for labor and delivery patient rooms compared to medical-surgical patient rooms (340 square feet minimum clear floor area vs. 120 square feet clear floor area).³¹ Larger rooms are needed to accommodate laboring and the procedural aspect of the delivery itself, as well as the expanded staff that accompanies the presence of a second patient (the infant) and specialists in case of an emergency. Therefore, large patient room size is a unique labor and delivery design challenge, which can be dealt with in more and less-efficient ways: Sharp Mary Birch Hospital for Women & Newborns Hospital has clustered their 22 rooms in such a way as to maximize efficiency and compactness between sets of rooms, even though the absolute maximum distance is the highest in our sample. In contrast, University Medical Center of Princeton at Plainsboro, which contends with the next highest distances between LDRS, has only 8 rooms, but the rooms are lined up along the periphery of a long, curving corridor - probably the least efficient arrangement.



Below

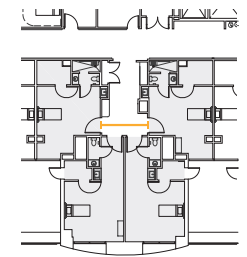
Alternate four-room arrangements can greatly affect travel distances between LDRs



University Medical Center of
Princeton at Plainsboro

Distance between four rooms

119'



Sharp Mary Birch Hospital for
Women & Newborns Hospital

Distance between four rooms

13'

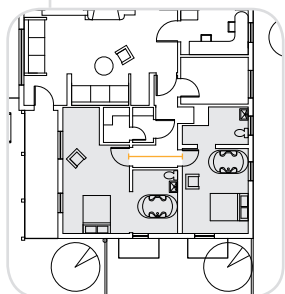
Maximum distance between LDRs

Measured variation within facility study set

LOW ● ● ● ● ● ● ● ● ● ● HIGH

9'

9'

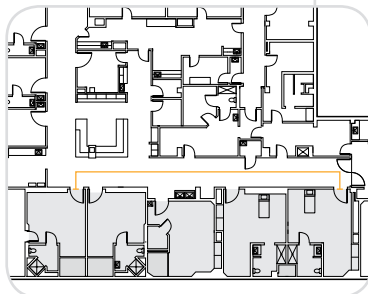


Dar a Luz Birth & Health Center

At Dar a Luz, the two birth suites are just steps from one another. In the case that both rooms are occupied by patients, midwives can easily move between rooms to monitor labors.

89'

89'



Merit Health Natchez

"It's easy to move around the unit."
-Director, Women's Services

217'

217'

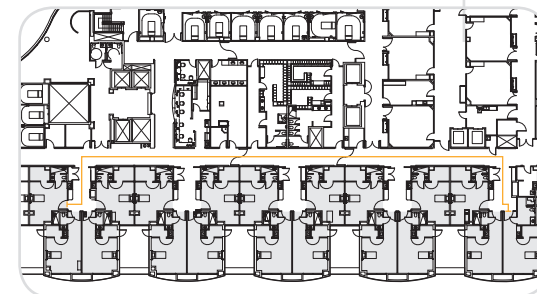


The Mother Baby Center

The Mother Baby Center complained that building codes required spacious LDRs, which necessarily increased travel distance between rooms. One physician acknowledged the tipping point at which a single-floor unit design becomes impractical (versus distributing the unit among several stacked floors) - **"otherwise you end up with the football field situation, taking forever to get from one place to another."**
-Obstetrician

242'

242'



Sharp Mary Birch Hospital for Women & Newborns

Because of the four-room pod layout at Sharp Mary Birch, the maximum distance between rooms is effectively 13' for floor nurses. Charge nurses and providers must still contend with the greater travel distance in carrying out their daily work. The pod structure also impedes distribution of workload, as nurses rely on only those 1 or 2 other nurses working in their individual pod to cover their patients for a break, for example. "The culture is so ingrained to be in a pod, that no one wants to leave the pod. We don't get our breaks." -Nurse Manager

"The path going from room to room to go to a supply room, it really kills our staffing."
-Director, Patient Care Services, University Medical Center of Princeton at Plainsboro

Workload

Distance between Workstations and Patient Rooms

Average distance from nurse station to LDR

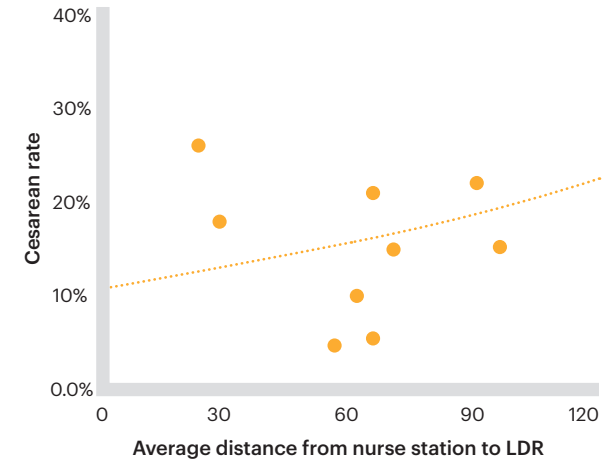
The nursing station is a central hub of activity on a labor and delivery unit. Many hospitals even refer to these locations as “control centers.” Sometimes they are used by physicians, midwives, and students in addition to nursing staff. Commonly, monitors that display fetal heart tracings and maternal vital signs for each patient, are found at the nursing station.

We found that distances between nursing station and LDRs vary widely, from an average distance of 23 feet at Sharp Mary Birch Hospital for Women & Newborns, where nurses sit just steps away from each of the four rooms in their pod, to an average distance of 114 feet at football-field sized University Medical Center of Princeton at Plainsboro, where nurses and physicians reported having to frequently run from room to room to care for patients.

We found that increasing average distance between the nursing station and LDRs may be associated with higher cesarean rates.

Distance between nursing stations and LDRs is affected by overall size and shape of the unit, with bigger units commonly necessitating proportionately more circulation than smaller units and long linear or labyrinthine units (University Medical Center of Princeton at Plainsboro and Woman’s) being less efficient than compact, racetrack-type units. As units grow in size, some hospitals employ a distributed nursing station model, wherein smaller sub-stations are located throughout the unit to increase patient access to nurses. We heard from facilities that this may have the unintended consequences of creating a barrier to provider/nurse communication. Beth Israel Deaconess Medical Center has found that proximity of LDRs to nursing stations threatens patient confidentiality:

“It’s very tiny [nursing station] – I worry about patient privacy. You don’t have any place to go to have a private or difficult conversation. Those things end up happening in the kitchen or med room.”

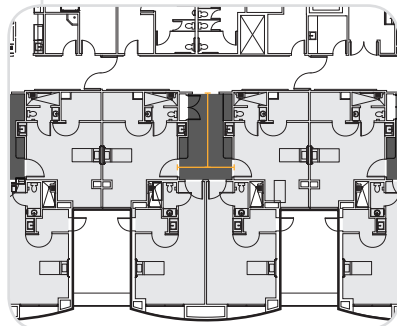
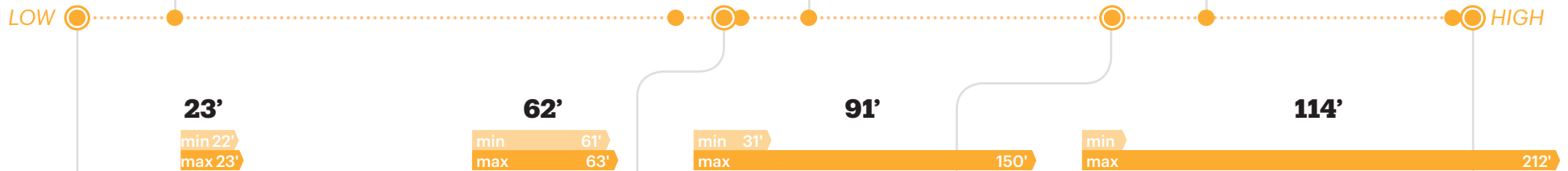


Despite proximity of LDRs to the nursing station at Tuba City Regional Health Care Corporation, the unit layout hinders efficient patient care. "If you want something, you have to either search for it or walk to the other end of the unit" (Acting Supervisor). The unit hasn't been significantly renovated since it was designed for a labor > delivery > recovery > postpartum model of care.

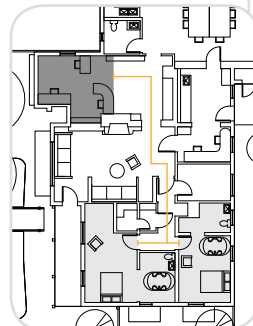
"We find ourselves using the old patient rooms because of their proximity to the nursing station, even though they're dingier. You're in and out so much, that you need to be close." -Director, Women's Services, Merit Health Natchez

Since moving to the new unit, nurses at The Mother Baby Center have struggled to adjust to the larger floor area and distances from their colleagues.

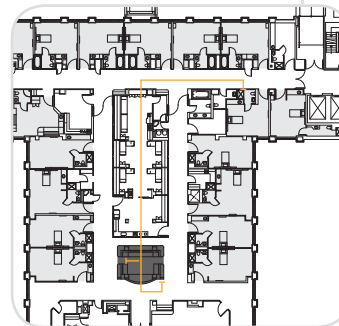
Average distance from nurse station to LDR
Measured variation within facility study set



**Sharp Mary Birch Hospital
for Women & Newborns**



**Dar a Luz Birth &
Health Center**



**Providence Portland
Medical Center**



**University Medical Center of
Princeton at Plainsboro**

The innovative four-room "pods" at Sharp Mary Birch Hospital for Women & Newborns are staffed by 2-4 nurses in mini stations. This distributed model of nursing station has decreased travel distance from nursing station to LDR with the intention of increasing patient access to nurses but has had unintended negative impacts on nursing collaboration and mentorship. **"It's the little things, like a nurse asking a senior nurse because you're all in the same pod and maybe someone overhears that and adds to the collaboration. That doesn't happen."** -Nurse Manager

"If you think about patient-centered care, you think about the safety of the patient and that takes a team. Yes, the nurse is very available. Can they be there in 10 seconds versus thirty? Sure. But...It's not just about distance." -Nurse Manager

"People were shedding pounds when we moved here. My friend works next door, she's been here for 6 months, she lost 17 pounds...and she wasn't a big girl!" -Nurse

- LDRs
- Nursing Stations
- Path (Nursing station > LDR)

* Drawings not to scale

Workload

Room Standardization

Degree of standardization of LDR interiors

Healthcare design experts frequently argue that standardization of the headwall location in patient rooms improves staff efficiency by reducing the effort required to reorient to a unique layout within each room. Theoretically, when rooms are standardized in this way, a nurse or clinician can enter any room on the unit and know immediately where to find necessary tools, rather than expending mental energy recalling the setup within a particular room. Based on this theory, we predicted that room standardization may decrease workload.

In our facility sample, we observed varying degrees of LDR standardization: from completely unique room layouts (more common among birth centers), to standardized but mirrored (same headwall layout but different sides in different rooms), to same-handed rooms (headwalls are located on the same side in each room). Our sample as a whole was evenly distributed among the three degrees of LDR standardization, but birth centers were uniformly non-standardized. Typically, birth centers occupy renovated houses or offices, where existing building conditions limit the options for standardization within labor and delivery rooms. Natchez was an outlier among hospitals - its five LDRs had fairly unique room layouts, resulting from a history of selective renovations to the unit.

Patient room standardization (specifically same-handed rooms) has been the subject of debate in healthcare architecture. Despite the commonly-held belief that standardization improves efficiency, there is little evidence to support the claim that same-handed rooms increase patient safety or staff efficiency over mirrored rooms.³² Furthermore, the construction requirements to

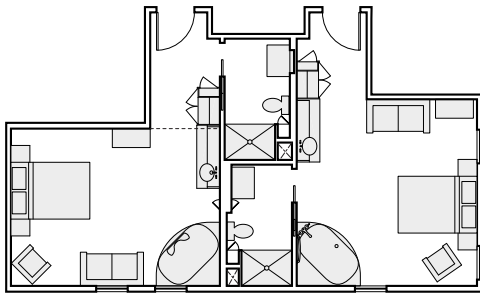
achieve same-handed rooms are significant and costly - adjacent rooms must each be afforded a separate chase for plumbing and medical gases, rather than sharing a common chase, greatly increasing the cost of construction for these facilities. Facilities with the financial resources to dedicate to new unit construction or renovation may be better able to implement same-handed rooms. Staff at University Medical Center of Princeton at Plainsboro indicated that same-handedness had actually negatively impacted efficiency - the additional chases required even larger LDRs, which further increased the distances between adjacent rooms.



Above
Facilities were evenly distributed along degree of room standardization.

LOW

Each room has unique room layout.

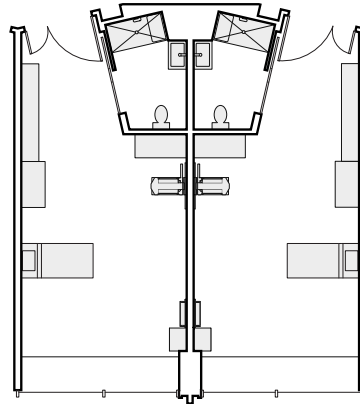


**Minnesota
Birth Center**

Typically, birth centers like Minnesota Birth Center occupy renovated houses or offices, where existing building conditions limit the options for standardization within labor and delivery rooms.

MEDIUM

Standardized room setup but mirrored back to back.

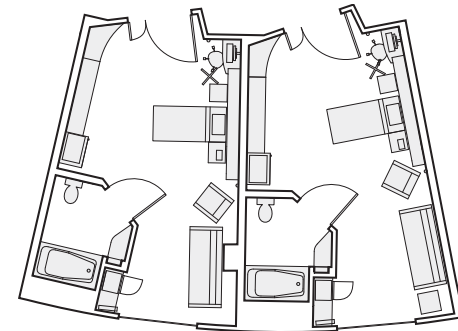


**University of Chicago
Medical Center**

Despite the commonly-held belief that standardization improves efficiency, there is little evidence to support the claim that same-handed rooms increase patient safety or staff efficiency over mirrored rooms, like this one.

HIGH

Same-handed rooms in which headwalls are located on the same side of each room.



**The Mother
Baby Center**

Staff at University Medical Center of Princeton at Plainsboro indicated that same-handedness had actually negatively impacted efficiency - the additional chases required even larger LDRs, which further increased the distances between adjacent rooms.

* Drawings not to scale



Motivation & Accountability

Motivation and accountability design elements theoretically impact the willingness and/or accountability of clinicians to exert effort in caring for patients. These were among the most exploratory elements we measured and included maximum distance from call room to labor and delivery room, ratio of total unit area to staff support areas, and ratio of total staff area to collaborative spaces.

Design Elements

Collaborative Spaces
Ratio of total staff area to collaborative staff areas

Accessibility of Call Rooms
Maximum distance from call rooms to LDR

Staff Support
Ratio of total unit area to staff support area

Hypotheses

Higher ratios of total staff areas to collaborative staff areas impede communication and team decision-making capacity, increasing treatment intensity.

Greater distance from call rooms to labor and delivery rooms makes it difficult to manage long labors, increasing treatment intensity.

Higher ratios of total unit area to staff support area decreases staff capacity to manage labor, increasing higher treatment intensity decisions.

Previous page

A collaborative area at Baby + Co. affords work stations for all members of the team

Motivation & Accountability

Collaborative Spaces

Ratio of total staff area to collaborative staff area

Opportunities to share knowledge and experiences and to communicate with colleagues in the course of normal workflow are critical to a sense of team accountability according to our advisory board. To capture these ideas, we analyzed the ratio of staff areas designed for collaborative interaction between team members to the total staff area. These collaborative areas could be either designated staff support areas or work areas - their identifying feature is their accessibility to (and actual use by) obstetricians, midwives and nurses for shared work. Higher ratios indicate relatively few collaborative spaces, while lower ratios indicate there are many spaces for collaborative engagement among the labor and delivery unit team. We predicted that collaborative spaces would lead to a greater sense of accountability to provide optimal care among team members and would drive treatment intensity down.

Among our facilities, ratios ranged from 1:1 (Minnesota Birth Center) to 0 (Woman's Hospital). Among hospitals, The Mother Baby Center has a very large proportion of collaborative staff spaces (nearly all), while Woman's has very few spaces which are collaborative in nature - staff work and take breaks as groups of nurses or providers, exclusive of the rest of the team.

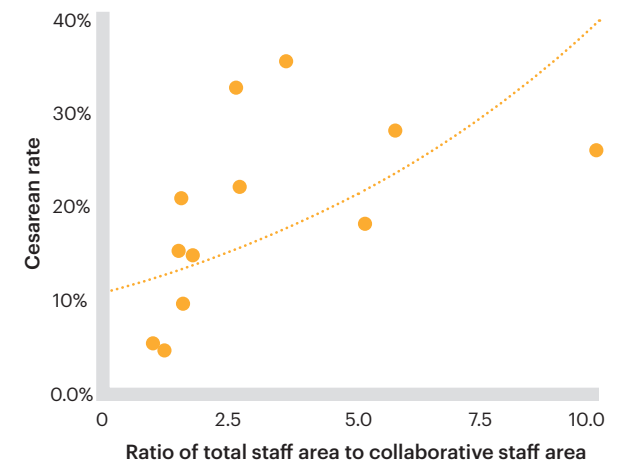
Some facilities like Beth Israel Deaconess Medical Center and Tuba City Regional Health Care Corporation Regional have a centrally-located common work area (although Beth Israel Deaconess Medical Center's unit is so short on work spaces they often take over the break room for team meetings instead). At Providence Portland Medical Center, inclusive team huddles happen in the hall outside of a snack room (adjacent to the nursing station).

Others separate work areas by staff role; at University of Chicago Medical Center, the "Board Room" is for physicians and midwives, while nurses enter only to give report. Merit Health Natchez's work areas are somewhat divided along staff roles as well.

Commonly, hospital unit break rooms are divided among staff as well. At Tuba City Regional Health Care Corporation, the space designated "Common Lounge" is, in practice, only for nursing, though it is rarely used because of its distance from the nursing station. Instead, nurses perch on a trash can lid in the patient kitchen to grab a snack, which is just down the hall. There can be a significant amount of jealousy around spaces exclusively for specific staff - the nurse-manager at Tuba City Regional Health Care Corporation tersely described the physicians-only lounge at her facility:

"Physicians are rarely on the unit [but] were given a lounge. I'm not sure exactly what it looks like, but I know that it probably has comfortable seating and food is provided for them. It's located off the OB unit and is for all the physicians in the hospital."

Our observations suggest the possibility of a positive relationship between a greater ratio of total staff area to collaborative staff areas to higher cesarean rates. Our contextual findings further clarify that increased accountability does not automatically translate into higher or lower cesarean rates without also understanding team culture and overall intentions. In tertiary settings, increased accountability may actually increase cesarean rates as patients are monitored more closely.



"Of course it makes sense to have everyone working in the same area. I don't know how we're going to achieve more of that in the new space. Ideally, it would be great to have nursing in the room as well."
 -Medical Director, Women's Services, University of Chicago Medical Center

- Collaborative Staff Spaces
- All Staff Spaces

* Drawings not to scale

Ratio of total staff area to collaborative staff area

Measured variation within facility study set

LOW  HIGH



Minnesota Birth Center

1:1

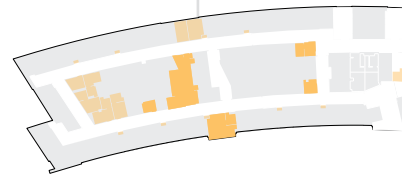
95% of staff spaces are collaborative



The Mother Baby Center

2:1

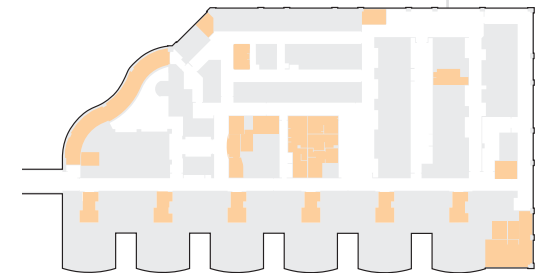
61% of staff spaces are collaborative



University Medical Center of Princeton at Plainsboro

4:1

27% of staff spaces are collaborative



Sharp Mary Birch Hospital for Women & Newborns

0

0% of staff spaces are collaborative

Much of Minnesota Birth Center's collaborative space comes from a large, partially-finished attic space, which is multifunctional as a call-room for midwives and a collaborative work space for all staff.

"We would really love to have ...a place to come together, because we used to have that and now we don't." -Head Nurse

"[S]ome kind of collaborative space where the nurses and the doctors can still be together is really important... That is a benefit to patient care. In this building we have the nurse's lounge and the doctor's lounge. So we find ourselves—or I do, often—sitting and having my dinner in the nurses lounge...that team aspect of things is very important in the care of patients." -Obstetrician

The new design has partly distributed nursing stations throughout the unit. Staff had a difficult time transitioning to a more isolated work environment. "Looking back, I think we would have done more to prepare for it. The social aspects...everyone used to be together. **We are so spread out that some people were really depressed.**" -Director, Patient Care Services

"It's kind of like we're in different units, but we're all in the same unit. The biggest thing is collaboration: with four generations working... **that's a lot of knowledge you could transfer and it's kind of blocked by walls.**" -Nurse Manager

Motivation & Accountability

Accessibility of Call Rooms

Maximum distance from call room to LDR

Call rooms are private rooms on or near a labor and delivery unit that provide physician and midwife staff an area for completing administrative work, resting, or sleeping during overnight shifts. As distance to call rooms increases, it may become more challenging for providers to use these spaces while also maintaining patient care responsibilities.

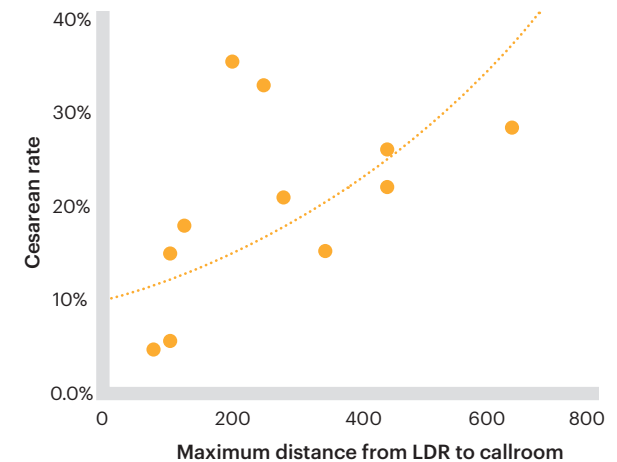
Location of call rooms with respect to LDRs varied greatly among facilities in our sample. At Dar a Luz Birth & Health Center, there are no call rooms - midwives typically spend their time at the bedside providing labor support. At some hospitals, call rooms are located so far from the unit, they are virtually inaccessible. Maximum distance from call rooms ranged from 88 feet at Baby + Co. to 661 feet at Woman's Hospital - a journey that winds into the core of the floorplate, past the ORs, beyond the extents of the labor and delivery unit. On average, call rooms were a maximum distance of 289 feet from LDRs.

Despite a large distance between Providence Portland Medical Center's block of call rooms (462 feet), staff didn't perceive inaccessibility to be a hindrance. In fact, the rooms are so frequently occupied that there are regular requests for more. For University Medical Center of Princeton at Plainsboro, where travel distances were the topic of most of our site visit, the call room placement was the least of their concerns: at 214 feet from the LDRs, clinicians feel that it's one place they can access without hindering the care of their patients - "actually they are closer than in the old hospital where we were, so not an issue there."

In isolation, we observed a relationship between maximum distance from call rooms to LDRs and cesarean rates among our sample.

Placement of call rooms relative to labor and delivery hinges on a number of additional considerations. During interviews and site visits we were often told that the quality or location of staff support areas, such as clinician call rooms, is sometimes sacrificed to patient-facing clinical areas. For example, at the University of Chicago Medical Center, two clinician call rooms located adjacent to the labor and delivery unit had been reappropriated for a patient waiting area. In addition to being a greater distance away, one obstetrician remarked that the calls rooms that remained were "disgusting" with this low quality further reducing their usability. At the Minnesota Birth Center, what was originally designed as a call room has now been designated a patient exam room when demand for non-maternity patient services expanded. Clinicians must now retreat to the birth center's attic, farther away from the LDRs, to use the call room. And yet, these spaces are highly valued (and coveted) by clinicians. During the University of Chicago Medical Center's recent redesign process, there was a great deal of discussion around call rooms:

"The amount of energy that was spent discussing a shower in a call room versus outside the call room versus the number of call rooms - that was exhausting. That was a huge thing. Having a suite of call rooms and a shared bathroom for female and male attending physicians - that was a big thing that people really got stuck on."

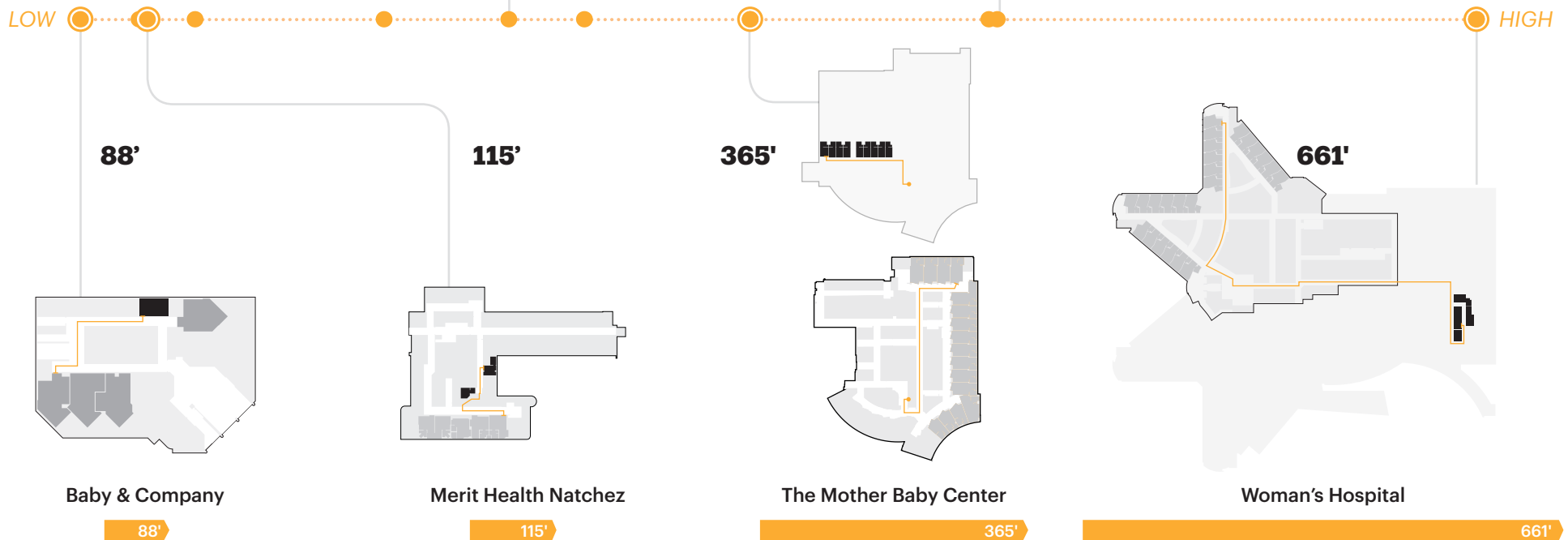


While travel distances are a frequently-cited concern at University Medical Center of Princeton at Plainsboro, distance to call rooms is perceived as less burdensome. OBs don't worry about the distances from a safety perspective, "because the on-call rooms are close by; actually they are closer than in the old hospital where we were."

It's 462' from an LDR to the farthest call room. **"It's not really that far."**
-Director, Perinatal Services,
Providence Portland Medical Center

- LDRs
- Physician/Midwife call room
- Path (call room > LDR)
- * Drawings not to scale

Maximum distance from LDR to callroom
Measured variation within facility study set



At Baby & Co., the midwife call room is designed to also serve as an overflow room for laboring patients. **"We almost never use it because we're with our patients."**
-Certified Nurse Midwife

At The Mother Baby Center, nine physician call rooms are located one floor above labor and delivery. **The fastest route requires an elevator ride and a walk down a long corridor.**

Anesthesiologists have dedicated call rooms within the labor and delivery unit but other providers must use a bank of twelve call rooms located off the unit, on the other end of the hospital floor - almost the length of **two football fields** away from the LDRs.

Motivation & Accountability

Staff Support

Ratio of total unit area to staff support area

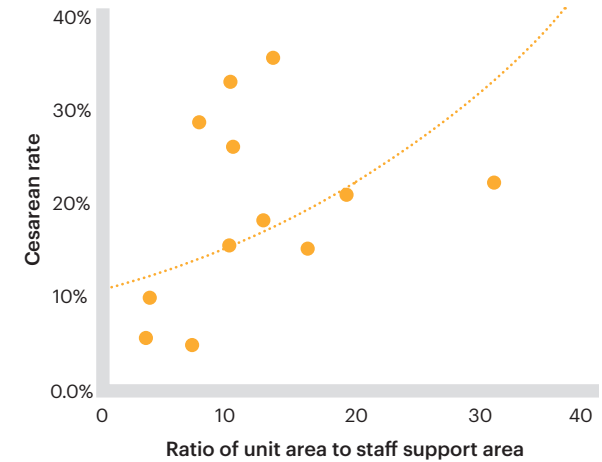
Labor and delivery staff rely on support spaces such as call rooms, locker rooms, break areas, and restrooms to step away from patient care - for a physical or mental break or to meet their own needs. Access to such spaces can alleviate perceived workload by facilitating breaks which are necessary for continued performance of clinical duties. Across our facility sample, we observed differences in the way staff are supported through the physical space. We evaluated availability of staff support spaces by determining a ratio of overall unit area to area allocated for these staff support functions: restrooms, staff break rooms, locker rooms, call rooms, and any other space that were reported to be used for a staff support function (e.g., at Providence Portland Medical Center, nurses have a “snack room” adjacent to the nursing station). A higher ratio of total unit area to staff support areas indicates relatively little area allocated for staff support, whereas low ratios indicate relatively greater accessibility of such areas.

Values ranged from 4:1 (Minnesota Birth Center and Dar a Luz Birth & Health Center) to 32:1 (Providence Portland Medical Center). The Minnesota Birth Center had a large proportion of staff support space due to a vast attic space that was multifunctional, but essentially served as a very large call room. In addition, and unique to the birth centers, much of the space allocated for staff support is shared with patients and families - a kitchen, dining room, or front porch where midwives might have lunch alongside an expectant father. Sharing spaces with patients increases the proportion of staff support space without sacrificing patient areas, but is a strategy not seen in any of our study hospitals, where there is greater spatial segregation of staff and patient families.

Of course, availability of such spaces doesn't necessarily guarantee their use. For example, we heard from several facilities that nurses often prefer to sit in the nurse's station rather than remove to a break room where they may lose the ability to monitor their patients or miss out on the social activity that occurs in these centralized work hubs. Physicians at University of Chicago Medical Center eat in their work room “because but it's just too difficult to use the staff lounge. You know, in an ideal world, they would just take a break and leave.” At Beth Israel Deaconess Medical Center, the staff locker room is “basically a big trash pit full of smelly shoes” - not utilized for daily storage at all.

Availability of staff support spaces is dependent upon a number of variables, including the size and layout of the unit and the type of staff who work on the unit (e.g. anesthesiologists, hospitalists, residents, students). In section 2.2 - 2.11.7 Support Areas for Staff, the FGI Guidelines stipulates that obstetrical units shall provide a staff lounge, staff storage facilities (like locker rooms or cabinets), and a staff restroom, but no specific recommendations are given for sizing or locating these spaces (even whether they need be on the unit). We observed that spaces for staff often take a back seat to patient areas during design and renovation processes. When University of Chicago Medical Center found themselves short on space during their recent unit relocation and design, staff were expected to forfeit their own spatial needs in the name of patient care:

“We got pushback on some of the changes, but I think that overall...clinical care is really what this unit is about. And the support spaces just ... are going to be smaller because we want to do the best thing we can for our patients.”




When space was needed to adopt a new triage system at the University of Chicago Medical Center, two call rooms were repurposed to create a triage waiting space for patients. **The remaining call rooms are "disgusting," according to an obstetrician on the unit.**

"The nurse's lounge isn't big enough for everyone to eat in all at once. It definitely wouldn't be if we put our refrigerator and microwave in there. They have to go heat their food in a separate room and then walk down the hall to eat. They just hate it. I know that seems petty, but **when you're here 12 hours, it's the little things like that that matter.**"

At Merit Health Natchez, the staff restroom is located down a long hall at the back of a storage room, making it relatively inaccessible. **"They're holding it as long as they can** because once they're way back in there, if someone needs help and they're calling them, they're not going to hear them." -Director,

At Beth Israel Deaconess Medical Center, "there are only two staff bathrooms on the unit and one is located inside the patient kitchen, which is awkward."

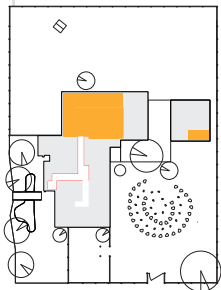
 Staff support spaces (break room or lounge, locker room, call room, restrooms, showers, lactation room)

* Drawings not to scale

Maximum distance from LDR to callroom
Measured variation within facility study set

LOW         HIGH

4:1



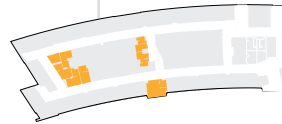
Dar a Luz Birth & Health Center

8:1



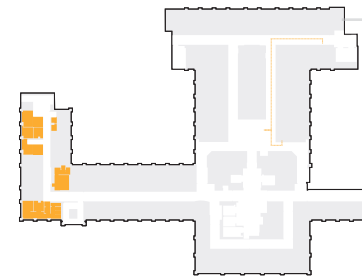
Woman's Hospital

14:1



University Medical Center of Princeton at Plainsboro

32:1



Providence Portland Medical Center

Unique to birth centers, staff support space is sometimes shared with patients. For example, at Dar a Luz, a kitchen/break room serves both staff and patient families - a midwife might share lunch alongside an expectant father. This is one way to increase the proportion of staff support space without sacrificing patient areas and a strategy not seen in any of our study hospitals.

Each "point" of the star-shaped unit is a mini-unit, called a "pod," with its own complex consisting of a nurse station, staff-only restrooms, medication room, supply closet, dictation room and meeting rooms. A break room is shared by the whole unit and features a large bay type window with a view of the surrounding ponds that were built on the property.

Four physician call rooms are each equipped with a bed, television, desk and shower.

Staff complain about the lack of sufficient call rooms, **"There's a battle going on right now over the call rooms - because they're always full."** But the designated break room goes underutilized because the work and social activity centers around the nursing station. "They don't like to go to the break room to take breaks. To get someone to walk to the back to take a break for 15 minutes is a culture shift. It becomes very comfortable, but it's not really best practice. We'd like to get people to get off the unit and take a real break to reduce nurse fatigue. But the culture right now is to huddle up with your buddies and visit [at the nurse station]. **If you go in the back, you're often sitting there by yourself and it's really not much fun.**" -Director of Perinatal Services



Contextual & Cultural Factors

One challenge in evaluating design elements in isolation is that they are likely to interact and pose collective influence on the activities of the facility. For example the annual deliveries per room, ratio of staff space to staff support space, and average distance from LDR to nursing station may all influence cesarean rates in concert. Moreover, design may impact a number of other contextual and cultural factors that are not easily ascertained with quantitative measurements. Examples of these contextual and cultural factors that we identified included accessibility of labor support equipment, prominence of technology, presence of natural light, and patient accessible circulation.

Design Elements

Hypotheses

Accessibility of labor support equipment

Increased acces to labor support equipment increases resources to manage physiologic labor, reducing treatment intensity.

Prominence of technology

Greater visual presence and use of technology increases reliance on interventionist labor practices, increasing treatment intensity.

Staff access to views and natural light

Access to views of outdoors or presence of natural light in provider work areas decreases stress/pressure on the unit, decreasing treatment intensity.

Patient accessible circulation
% unit circulation space available to patients

More area available for patient ambulation in labor facilitates physiologic labor, reducing treatment intensity.

Previous page

A labyrinth designed into the landscape of Dar a Luz Birth & Health Center welcomes women to walk in labor

Contextual & Cultural Factors

Accessibility of labor support equipment

Having the right tools for supporting labor can make it easier to provide appropriate care to patients. Labor tools such as birth balls, labor or birth tubs, birth stools, a rebozo, or a squat bar can assist women in various stages of labor. Access to these tools varies among childbirth facilities - from completely absent from the facility, to available but shared among rooms, to readily available at every bedside. We evaluated accessibility of labor support equipment on a low, medium or high scale.

Accessibility of labor tools was nearly evenly divided among our facilities. Commonly, the birth centers made support tools directly available in the labor and delivery room. One midwife at Baby & Company described the way they use labor tools to support women:

“[After the initial exam and triage] it’s about figuring out how to make her comfortable. What does she want to do? Do we want to fill the tub up, is she in her zone and we’re just supporting her? The pilates bar is great for the people that like to stand in labor and they want something to hold onto for support. Sometimes we’ll put towels here and so they can rest their head in between if they’re tired. Big soaker tubs, birthing stools...the tubs are super popular. Put a birthing ball in the shower. All of the water features have this wand, which moms like because then you can spray her lower back with warm water.”

Among hospitals, University Medical Center of Princeton at Plainsboro and The Mother Baby Center were also committed to providing many of these tools in each patient room in order to support physiological birth. At other facilities, labor tools were not as readily available to patients - for example, “We don’t use that type of stuff

here,” explained the Director of Women’s Services at Merit Health Natchez.

University of Chicago Medical Center had plans to purchase a mobile labor tub for their new unit, which would be stored centrally and relocated to patient rooms as desired. At Beth Israel Deaconess Medical Center, showers are not en suite in LDRs - patients who wish to use hydrotherapy for labor must walk down the hall to access two shared shower rooms. Likewise, at Tuba City Regional Health Care Corporation, patients share a single old cast-iron tub, located in a room in the core of the unit.

Design can promote access to labor support tools by providing adequate space to store these items. Staff at our facilities often complained about insufficient storage capacity. Large LDRs may be able to accommodate fixed equipment, like a labor or birth tub, or have ample storage for mobile equipment, like birth balls and stools. But, when space is limited in LDRs, as it frequently is in older facilities (whose small LDRs have been grandfathered into code compliance), equipment usually ends up in a single centralized storage closet, making it less prominent visually and more difficult to access when needed.

Accessibility of labor support equipment
Measured variation within facility study set



LOW

Labor support tools
unavailable

"We don't use that type
of stuff here."
-Merit Health Natchez,
Director of Women's
Services

MEDIUM

Labor support tools available but
stored outside of patient rooms



Left: Birth balls stored centrally in the
tub room at University Medical Center of
Princeton at Plainsboro.

"We have [labor tools] centrally located
only because we didn't design the
rooms to be able to incorporate that.
Our birthing balls, "peanut" balls,
and birthing bars are just so big that
between the case cart, the garbage
cans we keep inside and linen cans that
we keep behind the cabinets, we have
one cabinet left for the patient to use.
It's more of an issue of real estate than
anything." -Nurse Manager, Women's

Below: At Sharp Mary Birch Hospital for Women & Newborns, labor support tools are available on
the unit, but are stored in a central supply closet, making them a little more difficult to access.



HIGH

Labor support tools
accessible at each room



Above Birth ball and
birth stool in a patient
room at Baby & Co.

Below Birth balls packaged
and stored in a patient
room at Beth Israel Deacon-
ess Medical Center.



Contextual & Cultural Factors

Prominence of Technology

In some childbirth facilities, technology dominates the physical space - electronic fetal heart monitor screens tile the walls, CCTV security screens capture views of the locked unit doors, computer carts are parked in the corridors amidst a backdrop of pinging, sometimes-alarming machines. We rated prominence of technology along a continuum from low to high based on electronic fetal heart monitors as a proxy for total technology usage, where low ranking facilities use only intermittent monitoring (and no centralized monitors are present); medium ranking facilities use continuous monitoring and centralized monitors are present in work areas only; and high ranking facilities use continuous monitoring and maintain centralized monitors in both staff work and break areas.

In our facility sample, we observed a range of environments, from low- to high-tech. On one end of the spectrum was Dar a Luz Birth & Health Center birth center, where fetal heart tones are monitored intermittently by the midwives using a handheld doppler. In contrast, the “Board Room” at University of Chicago Medical Center, which serves as a clinician workroom and break room, was dominated by a wall of monitors, tracking on and off-unit pregnant patients and displaying fetal heart tracings for each. Clinicians documented on personal computers below. One obstetrician jokingly noted, “We’re going to be similarly irradiated in our new room with multiple monitors everywhere,” suggesting that the prominence of technology would be equivalent in their newly remodeled unit. The nursing station is similarly outfitted with monitor screens. Notably, in several units, we observed non-functional or non-utilized computer monitors cluttering the workspace. The halls of Beth Israel Deaconess Medical Center’s unit are cluttered

with various wheeled electronic equipment. Staff seem to coexist with these technical vestiges as a matter of course.

Ironically, some facilities which rely most heavily on electronic monitoring of their patients still utilize analog means of tracking patients. At Beth Israel Deaconess Medical Center, a small white board in a nursing station alcove is a strong anchor for staff - “people sit in front of the white board like it’s a drive in theater.”

Technology can also enter into care in other ways besides fetal heart monitoring. Communication systems varied from mobile phone systems, to wearable personnel-tracking devices to SMS texting. These devices have a presence in the visual (and auditory) field of the facility and potentially impact treatment intensity as well. One midwife at Baby + Co. described their use of text messaging to communicate amongst the team:

“We text each other all through the day...it’s a very secure, simple, easy way - non-invasive, because often their eyes are closed or she’s in her groove and you don’t have to interrupt that moment to communicate with someone else. I’ll literally tap out - COME NOW. Which is - my assistant knows - she’s pushing and we’re ready to have a birth. I don’t have to leave the room to go get her and come back.”

Factors affecting the prominence of technology include labor management practices (continuous vs. mobile vs. intermittent fetal heart monitoring), distribution and location of workstations, unit documentation standards (mobile electronic health record vs. fixed documentation stations vs. paper charting) and storage capacity (whether monitors and equipment can be tucked away or must be parked along the corridors).



Above

Medical equipment clutters the end of a corridor at University Medical Center of Princeton at Plainsboro

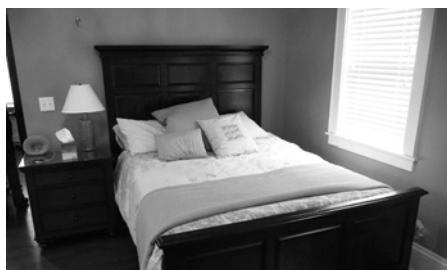
Prominence of technology

Measured variation within facility study set



LOW

intermittent monitoring exclusively;
no central monitors



Presence of technology at the bedside, The Minnesota Birth Center.



Midwives and nurses at Baby + Co. work in a station with laptop computers for documenting patient care, but the environment is free from central monitoring units because patients are monitored intermittently wherever they are laboring.



MEDIUM

central monitors present in
work areas only



The nursing station at The Mother Baby Center.



The nursing station at University Medical Center of Princeton at Plainsboro are also prominently feature central monitors.



Presence of technology at the bedside, The Mother Baby Center



Presence of technology at the bedside, University Medical Center of Princeton at Plainsboro.



HIGH

central monitors present in
both work and break areas



The walls of the Board Room at University of Chicago Medical Center are covered with monitors, tracking patient vitals, patient census statistics. As this room has a dual work room/break room function, technology is omnipresent for these providers.

"We're going to be similarly irradiated in our new room with multiple monitors everywhere," complained one obstetrician at the University of Chicago Medical Center, describing the monitors in the provider work and break room. -Executive Medical Director

"We have 5 computers at the nurse's station. The problem is that if someone is on it, charting, then you can't see your live tracing. So, that was the first problem we ran into. **We easily have five people jockeying for the computers.** So, they put up this "view only" screen [for fetal tracings]—across from nurse's station.... no one can fool with it." -Director, Women's Services, Merit Health Natchez

Contextual & Cultural Factors

Staff Access to Views and Natural Light

Some of the earliest findings in the evidence-based design literature supports the placement of windows in patient rooms, demonstrating improved clinical outcomes when patients have visual access to views outside (particularly of nature).³³ We rated facilities Low, Medium or High based on the amount of daylight in provider workspaces. The presence of natural light was ranked High if a facility had windows in provider workspaces; Medium if provider workspaces were daylit but had no views (e.g. a skylight above), and Low if provider workspaces were absent of daylight entirely. In all cases, we found that access to light fell to the extremes of this scale. Two of three birth centers provided windows in provider workstations - all other facilities ranked Low, meaning providers had no access to daylight in workspaces.

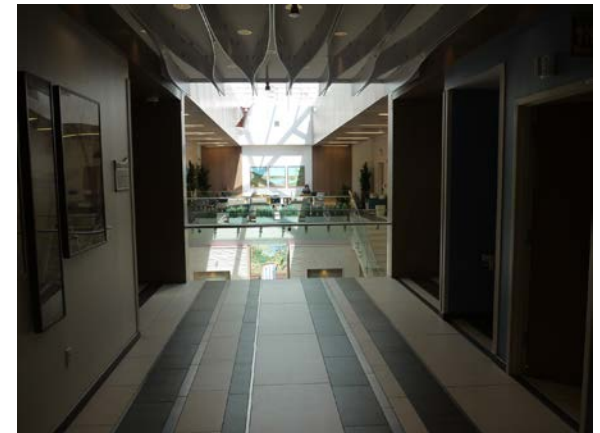
At Dar a Luz Birth & Health Center, which was designed to incorporate fresh air and exposure to nature into the birth process, midwife work areas feature operable windows with views of a carefully landscaped acre of surrounding land. However, Dar a Luz Birth & Health Center and the Minnesota Birth Center were unusual cases. Far more commonly, we observed that staff work areas were located in the core of a facility, as in Providence Portland Medical Center, Woman's Hospital and Sharp Mary Birch Hospital for Women & Newborns, or in the case of Baby + Co., along a windowless exterior wall. Midwives at Baby + Co. complained about the overhead fluorescent lights in their workroom, which they "never turn on." Instead, staff have outfitted the room with desk lamps.

While work areas were predominantly void of daylight, a few facilities had break rooms that afforded windows and, in some cases, stunning views (e.g. at Beth Israel

Deaconess Medical Center, where the break room is located at the corner of the unit and takes in nearly 180 degree views of the 1100-acre Emerald Necklace river parkway). Newly designed University Medical Center of Princeton at Plainsboro architects were critiqued by staff for having prioritized "daylight and not much else" in their design of the labor and delivery unit. Even so, daylit spaces penetrate only as far as the peripheral interior of the building - reaching patient rooms and the staff lounge. Worthy of special attention is the unusual layout of the Sharp Mary Birch Hospital for Women & Newborns unit, which affords a long, curvaceous, windowed exterior wall for a physician's lounge - meanwhile, the patient waiting area is located immediately adjacent and interior, without windows or daylighting.

The presence or absence of windows in clinician workspaces depends on multiple factors. In recent years, hospital units have responded to increased patient volume and emphasis on improving the patient experience by widening the typical floor plate and positioning patient rooms along the exterior. Areas allocated for staff work and support, storage, and technical services (labs, ORs, technology) are moved to the core, where access to windows is unavailable. Advances in mechanical HVAC systems coincided with and enabled this trend in hospital floorplan design. The distribution of staff spaces in our hospital units can be explained, in large part, by this historical context.

There are ways of directing daylight into the core of a building, namely through the use of courtyard spaces or skylights. The usability of this strategy depends on the level of the unit within the building. The Mother Baby Center uniquely uses this strategy to illuminate an interior grand stairwell joining third and fourth floor waiting areas (see photo). However, courtyard typologies are uncommon among U.S. hospitals.



Above

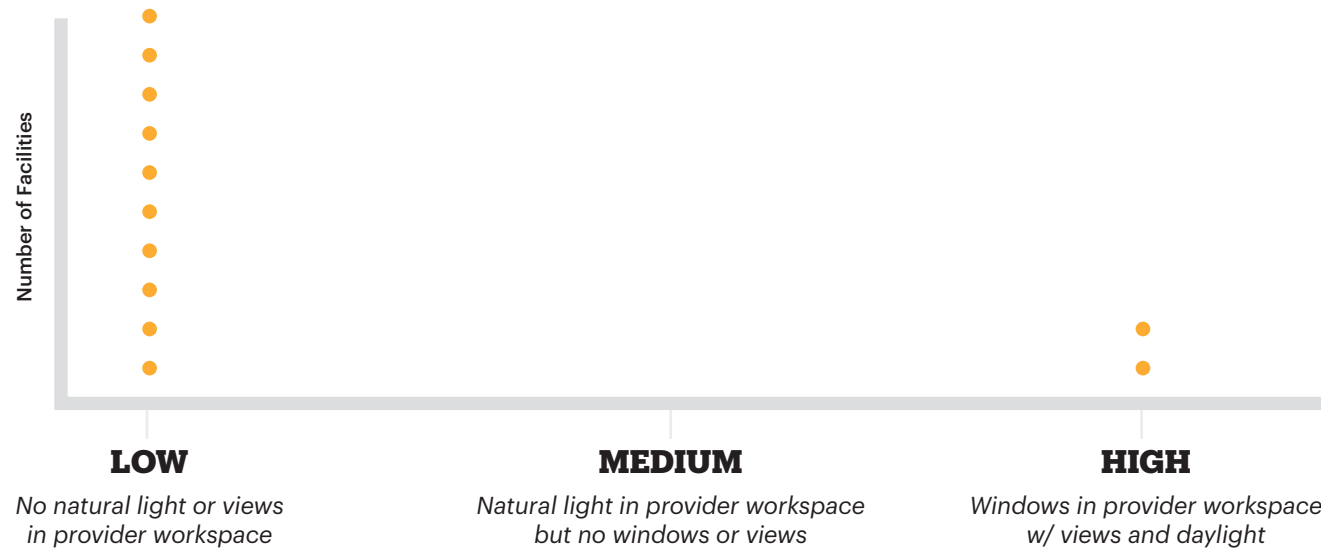
The physician's lounge at Sharp Mary Birch Hospital for Women & Newborns has ample access to light and sweeping views. Photo: www.sharp.com

Below

A skylight introduces natural light into an interior patient waiting area at The Mother Baby Center.

**Staff access to views
and natural light**

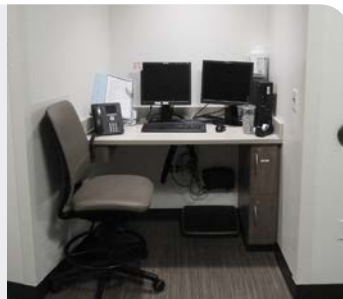
*Measured variation
within facility study set*



Workstation at Beth Israel Deaconess Medical Center. Fluorescent Lights.



Central nursing station at The Mother Baby Center.



Workstations at The Mother Baby Center.

At University Medical Center of Princeton at Plainsboro (right), the architects focused on daylighting the patient spaces as a top priority; **even the LDR closets have windows**. But there is no natural light in provider work areas.

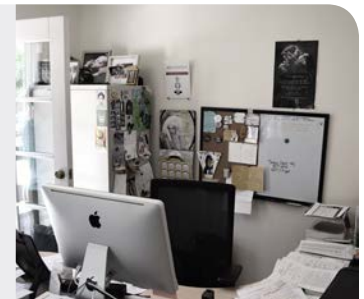


View from a patient room at University Medical Center of Princeton at Plainsboro.



Neither the central nursing stations nor distributed work stations are naturally lit.

When midwives at Dar a Luz were planning the design of their birth center, operable windows were a priority - for both patients and staff to have **"...fresh air. And the sound of birds and water and views of natural things instead of views of the parking lot or the building right in front of you."**
-Certified Nurse Midwife and Executive Director



Dar a Luz Birth & Health Center provider workspace



Minnesota Birth Center, provider workspaces



Minnesota Birth Center, provider workspaces

Contextual & Cultural Factors

Patient-accessible Circulation

% unit circulation space available to patients

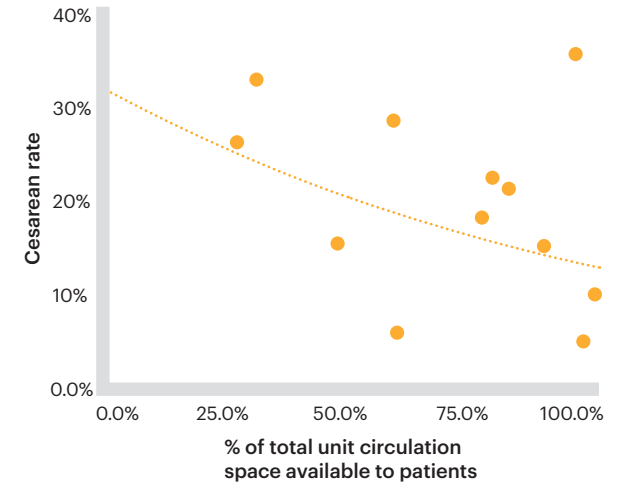
Patient ambulation during labor - “labor walking” - is a commonly-acknowledged means of facilitating physiologic birth. However, facilities vary tremendously in their capacity to accommodate women walking in labor outside of the LDR. We asked facilities to confirm the portions of their overall unit/facility circulation which were theoretically accessible to patients and calculated the percent of patient-accessible circulation. We predicted that facilities with higher percentages of patient-accessible circulation would benefit from this additional labor ‘tool’ and see lower treatment intensity as a result.

Percent of patient-accessible circulation ranged from 28% to 100% of the total facility circulation. At Sharp Mary Birch Hospital for Women & Newborns, patients are generally restricted to the linear corridor that runs the length of the labor and delivery rooms. In contrast, the director of Dar a Luz Birth & Health Center sought a property that could maximize both indoor and outdoor areas for patients to move around during labor. The landscaping of the site was intentionally designed to support this aspect of their model of care.

Overall, we observed that facilities with higher percentages of patient-accessible circulation, like Dar a Luz Birth & Health Center, Baby + Co., and Tuba City Regional Health Care Corporation had lower treatment intensity, whereas Sharp Mary Birch Center for Women & Newborns and others with few patient-accessible spaces, had higher treatment intensity.

In addition to the quantitative analysis of this metric, certain qualities of patient-accessible space clearly make it more or less suitable for supporting women in labor. The project architect for The Mother Baby Center’s new unit admitted that the “little section of hallway that their room opens out onto” was insufficient space for a patient wanting to labor walk. Staff at the University of Chicago Medical Center recognized that continuous loops are preferable to long corridors - their new unit plan specifically incorporated a patient-accessible loop in their overall circulation plan.

There is variation, too, in the meaning of “patient-accessibility” across facilities. At Merit Health Natchez, 88% of the total circulation is theoretically accessible to patients; in reality, because of the model of care that relies heavily on induction of labor (according to the director, 75% of admissions are scheduled inductions), patients are restricted to beds, where they can be continuously monitored. Difficult to capture with metrics, too, is the difference between a space where patients are technically permitted and one which invites patient use.



Left

An uninviting but technically patient-accessible corridor at Beth Israel Deaconness Medical Center

Right

Labor labyrinth landscape feature at Dar a Luz Birth & Health Center



Conclusion/Discussion

Design Process Insights

Our observations in this project offered early insight into how design processes may be improved going forward. Seven of our study's twelve facilities were either currently undertaking or had recently completed a major renovation or new unit design. In addition to these large-scale projects, we found that most facilities take on some smaller-scale modifications to the design or layout of their unit at two to three year intervals, including interior "facelifts" (new surface treatments, replacing outdated furniture, painting) and adjustments to the allocation of space (e.g. University of Chicago Medical Center's re-purposing of two call rooms to serve as a patient waiting area). Despite the common and frequent experience of design or renovation, there seems to be very little transfer of lessons or best practices between facilities. Within facilities, end-users are not always fully engaged in redesign efforts and work-arounds imposed by existing designs may not be consistently understood.

Through our discussions with the team members involved in both small and large-scale design interventions, we gathered several process suggestions and lessons learned.

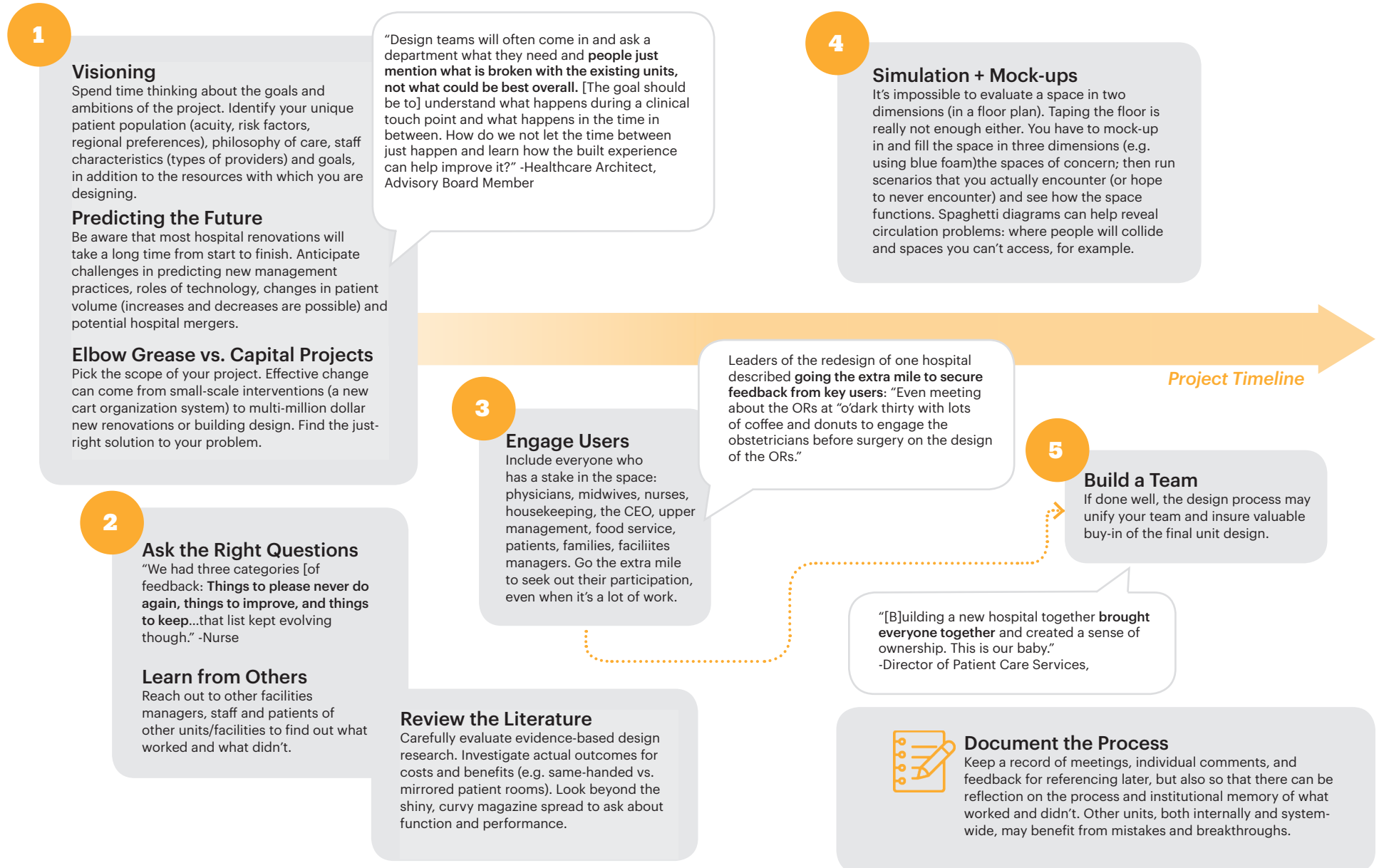
Beyond these process improvement insights, our observations collectively clarify many of the ways that design can either help or hinder clinicians in caring for patients, particularly with regard to enabling flexibility/adaptability in responding to changing patient needs, facilitating knowledge sharing and distribution of workload, and creating physical or cognitive "anchors" that reinforce certain patterns of work. Our observations also suggest the possibility of an association between facility design and important outcomes such as cesarean delivery, and provide the basis for a number of specific testable hypotheses for how quantitative and qualitative

design metrics may be linked with processes of care.

Future work may test these hypotheses using a larger sample of facilities and greater granularity with regard to clinical practice or management preferences. For example, the effect of capacity on cesareans might be best understood with greater information on patient admission policies or the criteria for and frequency of using overflow beds; the effect of workload on cesareans might be better understood with information on how travel distances impact the assignment of nurses to patients. Greater socioeconomic context such as the percentage of patients covered by Medicaid may better elucidate the role of design in sustaining or alleviating disparities in care. Collectively, these data may provide insights that help mitigate the risk of propagating design choices that are expensive, harmful, or both. By combining evidence-based design with improvements to design processes, we hope to provide helpful guidance to clinician-architect collaborators who intend to build environments that support better care at lower cost.

Learnings: The Design Process

Common design process recommendations, gleaned from study facilities which have recently undertaken large-scale renovations.



APPENDIX

Research Team



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Glossary

Adjacency

Areas located beside one another. e.g. an OR is usually adjacent to post-operative rooms.

Anesthesiologist

Physician who specializes in anesthesia for c-sections and labor pain control; often dedicated obstetrics anesthesiologists.

Annotations

Notes overlaid on an architectural drawing to convey additional information not described by the drawing itself.

CAD

Computer-aided Design. Software used by architects to create precision drawings or technical illustrations in 2- or 3-D.

Circulation

Area of a building used for moving people from place to place. E.g. hallways, elevators, footpaths.

Doula

Non-medical staff trained to provide physical and emotional support to women during labor, childbirth and postpartum.

Footprint

Outline of the building area that meets the ground plane.

Headwall

In a hospital room, the wall behind the head of the bed. Usually contains fixtures for medical gases and equipment.

LDR

A model of delivery room in which women labor, deliver and recover in one space.

LDRP

A model of delivery room in which women spend labor, delivery, recovery and postpartum in one space. Alternative to LDR.

Maternal Fetal Medicine

Obstetrician (MD) who specializes in treating women and babies throughout high risk pregnancies.

Midwife

Provider with specialized training in pregnancy and childbirth care; in the hospital setting, usually a certified nurse midwife (CNM) who holds a nursing degree.

Neonatologist

Physician (MD) who specializes in caring for newborns, especially those in need of more intensive care.

Obstetrician

Physician (MD) who specializes in pregnancy and childbirth care.

Plan

Architectural drawing which shows a space from above, as if the building were cut through at approximately 4' above the floor. Also known as Floor Plan.

Program

The uses, functions and needs of a space or building which need to be accommodated.

Resident

Physician (MD) in training.

Scale

Element of an architectural drawing which indicates the size of the drawing in relationship to the actual building or space. Can be written or graphic.

Staff Nurse

Nurse (RN) who provides direct care to laboring patients.

Unit Manager

Nurse (RN) who monitors labor floor resources (beds, staffing, etc.) and patient flow; usually has limited or no clinical role.

Unit Secretary

Administrative role for registering patients and scheduling planned cases.

Baby & Co Nashville TN

FREESTANDING BIRTH CENTER

This Nashville birth center is one of five Baby + Co. facilities located throughout the U.S. Births are attended by CNMs who have a close working relationship with nearby Vanderbilt University Medical Center, although care is still transferred if a patient requires in-hospital care. Baby + Co. offers a boutique birth center experience, aiming to feel “better than home.”

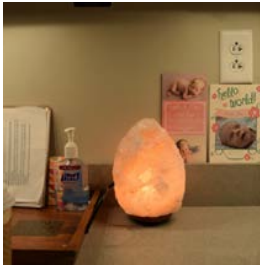


The Quiet Room offers a space for hearing difficult news (about a miscarriage, for example). Women can leave through a private door, so they don't have to walk through a waiting room past healthy moms and babies and celebrating families.

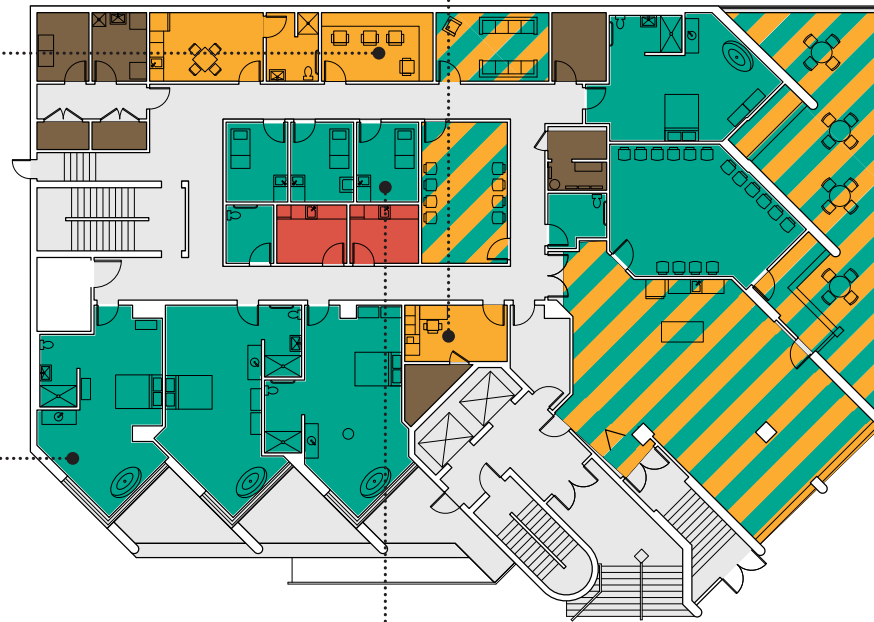
5.1%
CESAREAN RATE

300
ANNUAL DELIVERIES

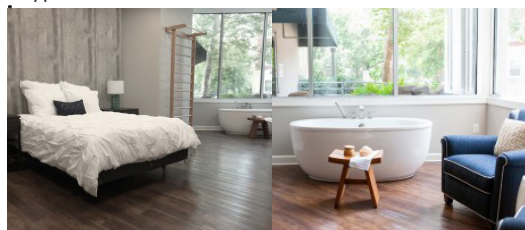
75
BIRTHS/L&D ROOM



Priority is given to patients and families for natural light. While birth suites and the waiting room are flooded with light and views to outdoors, staff work in the back in a windowless office. To compensate, midwives decorate their office with a salt lamp and rarely turn on the overhead fluorescent lights.



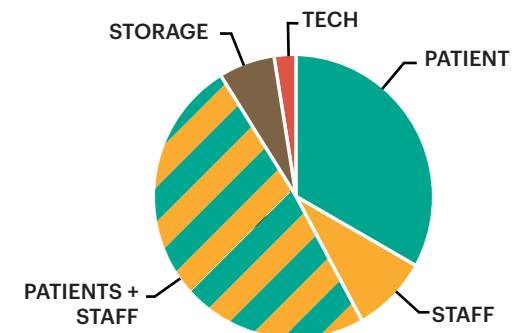
Typical birth suite



Three exam rooms were included in the design, but have been underutilized. Nurse-midwives prefer to host patients in the birth suites to familiarize them with the space before their birth. One exam room has been sublet to a lactation consultant as an additional source of revenue for the birth center.



If an emergency hospital transfer is required, EMS parks on the street in front, and accesses the center through an underground parking garage, entering the lobby through elevators. This approach, which is dictated by the physical structure, frames the interaction between nurse-midwives and paramedics, allowing nurse-midwives to retain control of the clinical situation.



Dar a Luz Birth & Health Center Albuquerque NM

FREESTANDING BIRTH CENTER

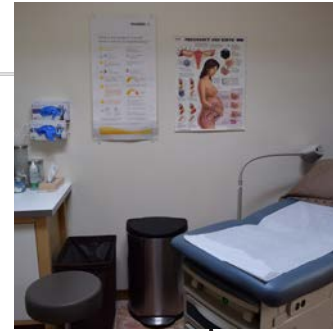
Dar a Luz Birth & Health Center, a non-profit birth center located in suburban Albuquerque, opened in 2011 after an arduous and trailblazing state facility licensing process. The center accepts private insurance as well as Medicaid and sees an ethnically and religiously diverse population of women.



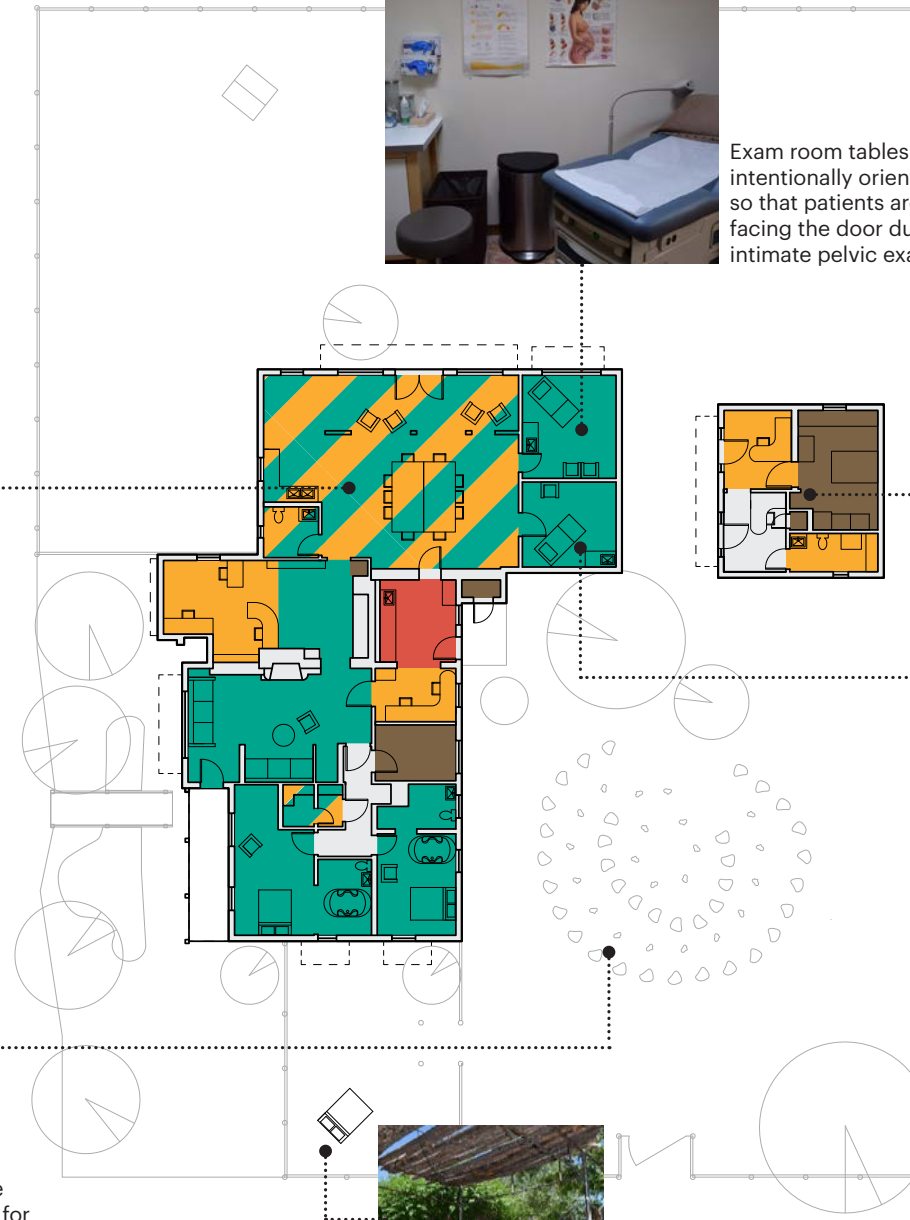
The skylight room serves both as gathering/waiting space for expectant families and staff as well as education area; the adjacent kitchen is used by staff and patients alike.



Dar a Luz's large property allows for extensive landscape design, including a stone labyrinth and outdoor room, which facilitates outdoor walking during labor.

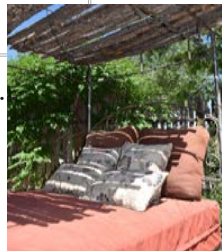
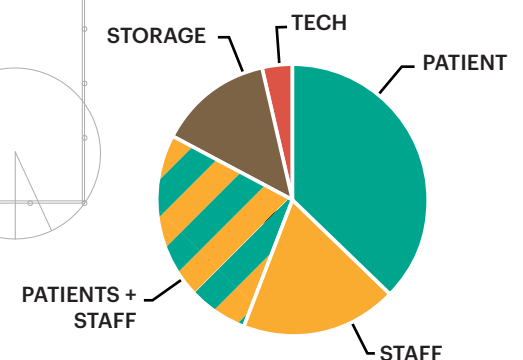


Exam room tables are intentionally oriented so that patients are not facing the door during an intimate pelvic exam.



Most administrative and storage areas are in a separate building entirely.

Exam rooms serve as overflow space for labor and delivery or recovery when needed.



An outdoor labor bed

10%
CESAREAN RATE

200
ANNUAL DELIVERIES

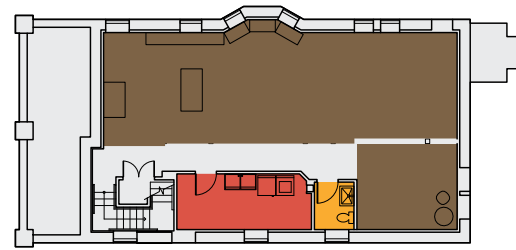
100
BIRTHS/L&D ROOM

Minnesota Birth Center Minneapolis MN

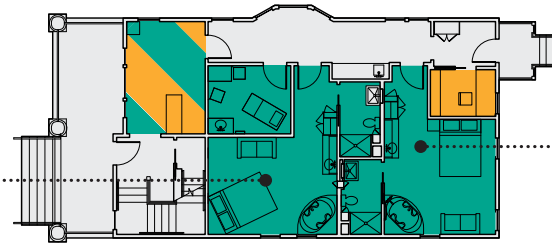
FREESTANDING BIRTH CENTER

The Minnesota Birth Center is actually two centers located in the Twin Cities. Because of their close affiliation, the St. Paul center (located 7 miles away) functions almost as an overflow facility. The Minneapolis center is housed in a renovated multilevel Victorian house, which defines (and in some cases restricts) layout.

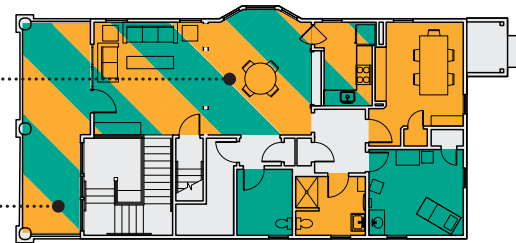
Unique to MBC are the birthing slings hung from reinforced D-rings in the ceiling of each birthing room. Approximately 40% of the births at MBC take place either in the sling or on a birthing ball or some alternative to the bed.



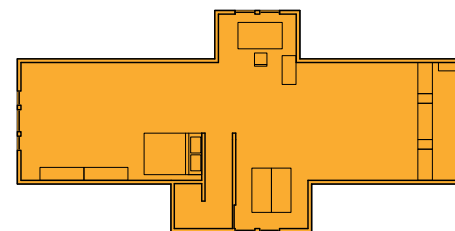
Basement



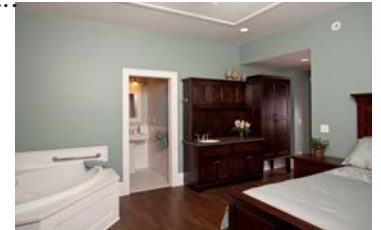
1st Floor



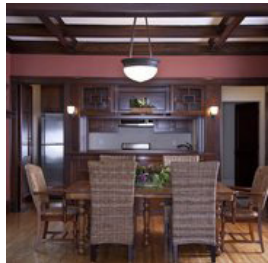
2nd Floor



Attic

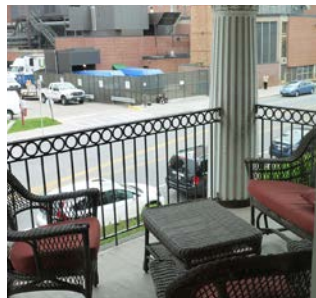


The two birthing rooms at MBC are unique to one another in layout, however the cabinets in each room are stocked identically to reduce cognitive load on providers; a pattern that is consistent across the St. Paul and Minneapolis locations.



Patients, families and providers share lounge space in the home's kitchen and dining rooms.

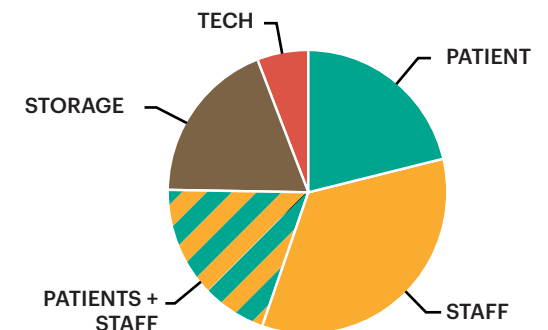
The porch on the second floor of the birthing center provides outdoor dining space for both staff and family members.



6%
CESAREAN RATE

176
ANNUAL DELIVERIES

88
BIRTHS/L&D ROOM

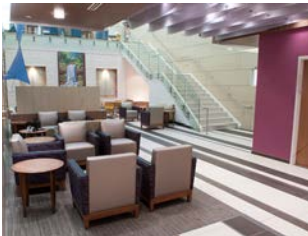


The Mother Baby Center Minneapolis MN

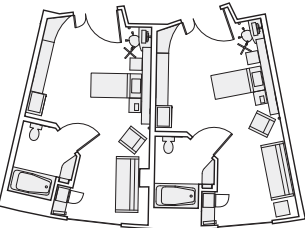
COMMUNITY HOSPITAL UNIT

The Mother Baby Center is located on the Abbott Northwestern and Children’s Hospital Campus. The unit was renovated in 2010 to enhance revenue and to provide more efficient patient care (previously clinicians “sprinted” between maternity and newborn services). Since the renovation, the unit has seen a large delivery volume increase, which wasn’t anticipated.

The Celebration Plaza waiting area is located in the core of a deep floor plate but its double height gives the space an open and brightly lit feeling. The grand stair leads up to one of two postpartum floors.



Same-handed rooms aim to reduce cognitive load on providers and nurses by decreasing time needed to reorient oneself to the layout of each room while managing multiple patients. However this also doubles the number of plumbing shafts needed, driving costs up.



Decentralized and distributed nursing stations throughout the large floor plan facilitate collaborative work, while individual work stations are located outside each room for focused patient documentation.

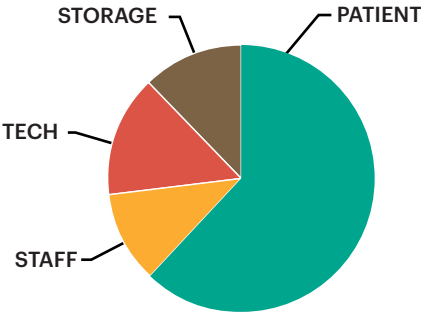


15.4%
CESAREAN RATE

5400
ANNUAL DELIVERIES

225
BIRTHS/L&D ROOM

The Mother Baby Center’s unusual floor plan shape is partly informed by a need to fit the department into a packed hospital campus, while preserving patient access to views.



Woman's Hospital Baton Rouge LA

WOMEN'S SPECIALTY HOSPITAL

Woman's, a private, nonprofit organization founded in 1968 is one of the largest women's specialty hospitals in the United States. The current unit opened in 2012.



28%
CESAREAN RATE

8455
ANNUAL DELIVERIES

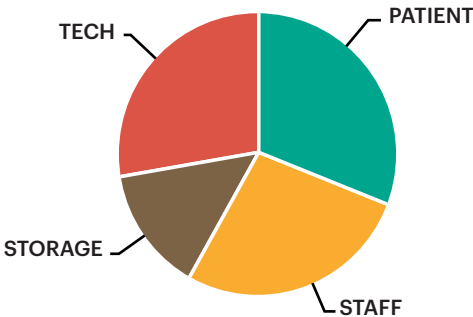
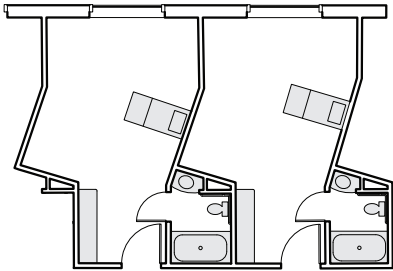
343
BIRTHS/L&D ROOM

In this distributed nursing station model, each "point" of the star is a mini-unit, with it's own nursing station complex (consisting of work area, lounge, restrooms, medication room, supply closet, dictation room and meeting rooms).

Co-locating related services on a single floor (e.g. the adjacent antepartum unit here) reduces workload for providers managing patients across services.

The unusual star-shaped layout maximizes the number of patient rooms along the exterior wall, affording windows with sweeping views.

Same-handed rooms aim to reduce cognitive load on providers and nurses - decreasing time needed to reorient oneself to the layout of each room while managing multiple patients.



Providence Portland Medical Center Portland OR

COMMUNITY HOSPITAL UNIT

PPMC is a community hospital primarily serving the East side of the Portland metro area. The unit completed renovations in 2011, reverting to an LDR room model from LDRPs, in order to better deal with an increase in annual delivery volume.



Exterior view at main entry

22.4%

CESAREAN RATE

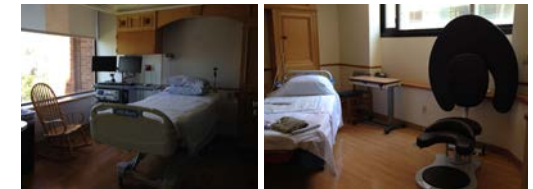
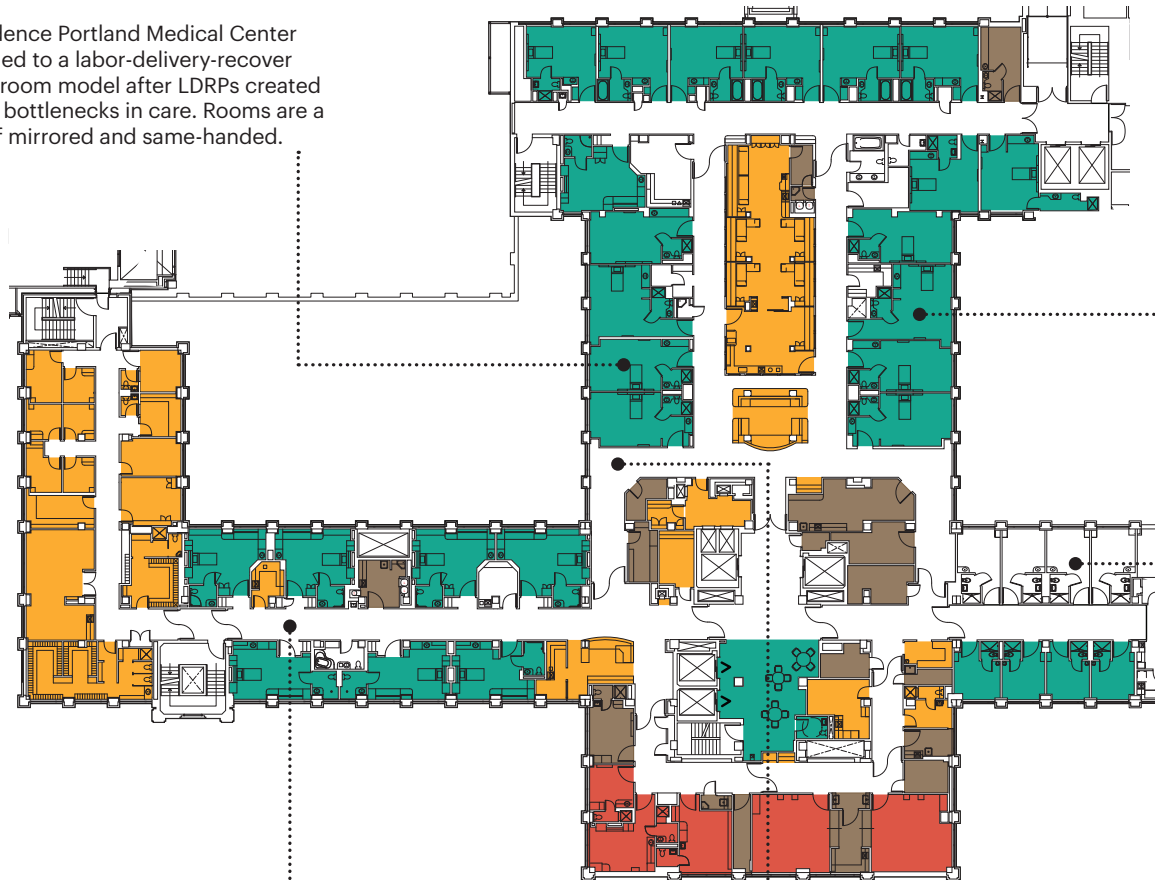
2471

ANNUAL DELIVERIES

145

BIRTHS/L&D ROOM

Providence Portland Medical Center returned to a labor-delivery-recover (LDR) room model after LDRPs created major bottlenecks in care. Rooms are a mix of mirrored and same-handed.

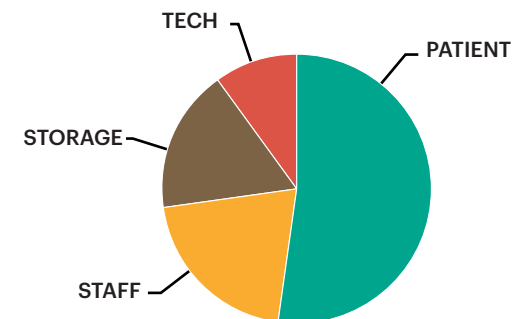


Typical labor and delivery room (left) and Pregnancy Care Package Room (right) options.

The labor and delivery unit is embedded within a larger floor plan that includes related services including postpartum and antepartum units. This design decision reduces workload for providers managing patients on multiple services.

The racetrack unit typology provides an opportunity for patient ambulation during labor.

A corner near the nursing station (and near a popular staff snack area) provides space for team huddles. A benchmarking board keeps the team aware of performance.



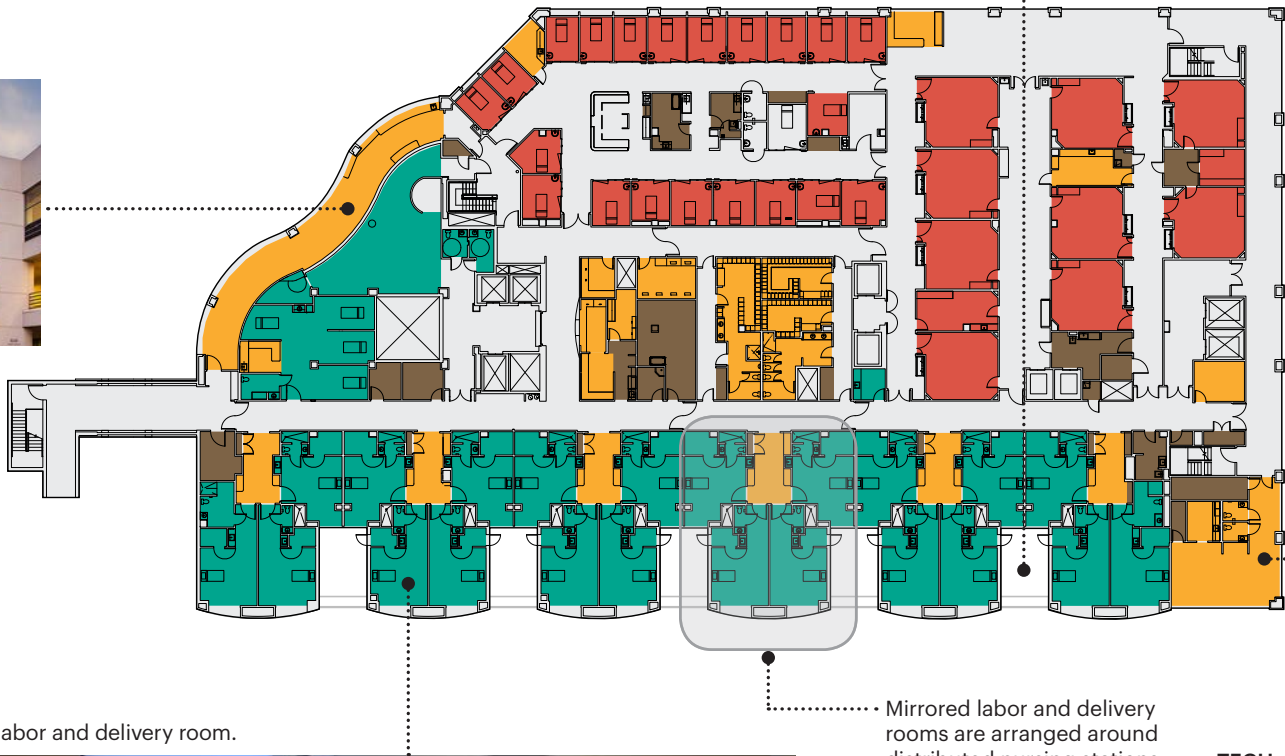
Sharp Mary Birch Hospital for Women & Newborns San Diego CA

WOMEN'S SPECIALTY COMMUNITY HOSPITAL

Opened in 1992, Sharp Mary Birch has one of the largest level III neonatal intensive care units in Southern California and has the largest annual delivery volume of any hospital in the state.



Physicians at Sharp Mary Birch Hospital for Women & Newborns are afforded expansive views from their exclusive lounge.



Panorama of typical patient labor and delivery room.



The balconies located between LDRs were never meant to be occupiable, but were to feature planters to enhance patient views. Maintenance ceased when concerns were raised over water usage and patient privacy. The balconies are now locked and empty.

25.8%

CESAREAN RATE

9100

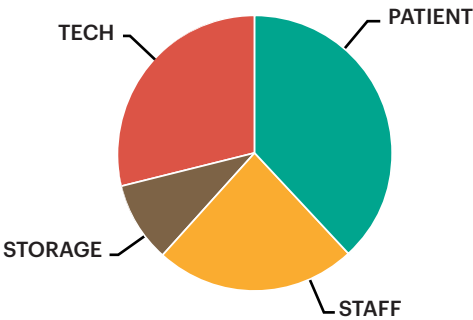
ANNUAL DELIVERIES

479

BIRTHS/L&D ROOM

Staff have divided break spaces - but the nurse lounge (located on the opposite end of the unit from the physicians's lounge) also features views.

Mirrored labor and delivery rooms are arranged around distributed nursing stations - each "pod" operates fairly independently.



Merit Health Natchez

Natchez MS

COMMUNITY HOSPITAL

The 2015 consolidation of two small community hospitals required the renovation of an existing facility in Natchez, Mississippi. The design was driven by a need to accommodate increased annual deliveries and modernize patient rooms with updated amenities like ensuite showers. The hospital has no NICU, so patients are transferred to the University of Mississippi in Jackson (120 miles away) by EMS or helicopter.



Merit Health Natchez exterior

15.0%
CESAREAN RATE

888
ANNUAL DELIVERIES

178
BIRTHS/L&D ROOM

The nursery is used, but more and more infrequently, as the hospital moves to babies "rooming in" as the standard of care. A dedicated team of nurses staffs this area, working in the adjacent work area, away from L + D nurses.

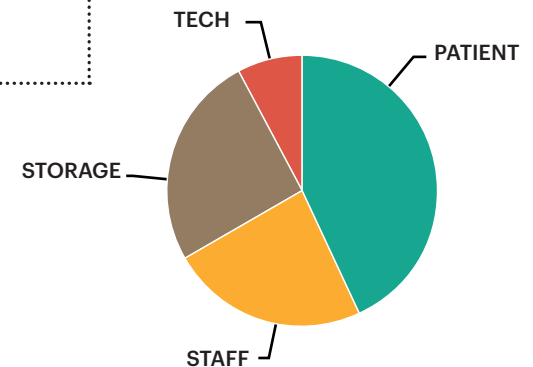
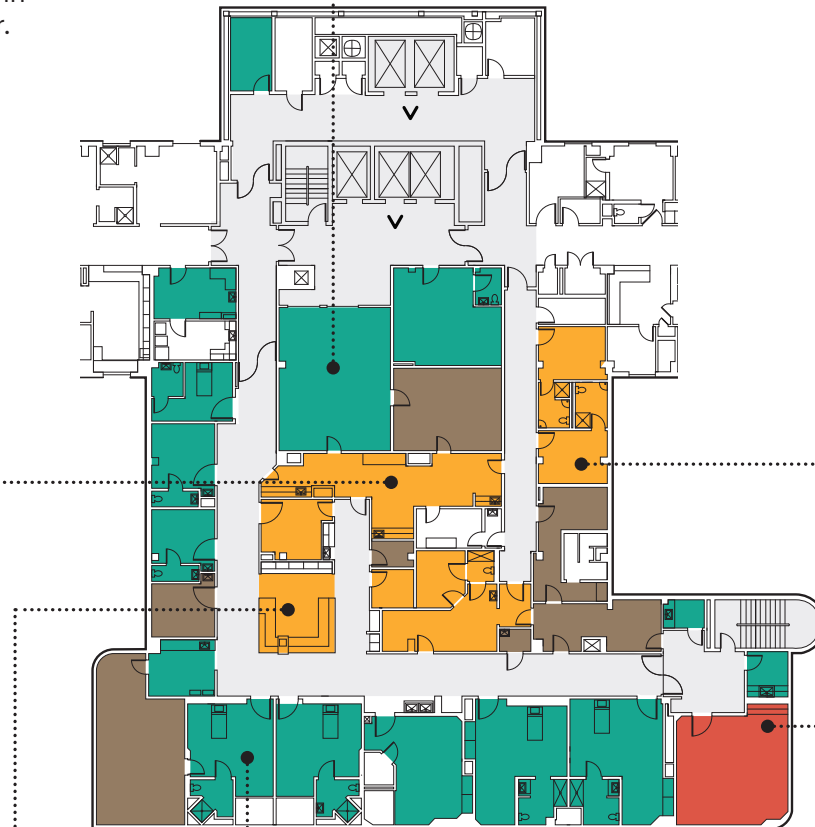
Staff areas have changed functionally, as needed, to increase efficiency and maximize storage. Space designed as a male locker room has been converted to a doctor's lounge; a designated storage area close to the central work station made more sense as a nurse lounge; and what was designed as an all staff lounge now stores equipment.

Natchez opted for only one OR when they renovated their unit in 2015. This decision allowed them to add one additional labor and delivery room. Two simultaneous c-sections were such a rare occurrence and the hospital's general surgery department is directly below and readily accessible to the labor and delivery unit.

Nursing and staff areas are located in the core of the building, without access to natural light or views to the outdoors.

The central work station is used collaboratively, by both nurses and physicians, to exchange information, as well as document patient care. However, physicians and nurses have separate lounges.

Though modernization was a priority for the hospital's postpartum room (located in an adjacent wing), the labor and delivery rooms windowless.



Beth Israel Deaconess Medical Center Boston MA

ACADEMIC HOSPITAL

A Harvard Medical School-affiliated, major academic teaching hospital, Beth Israel is located in the dense healthcare landscape of Boston Longwood Medical Area. Housed within one of the largest medical centers in New England, the BI labor and delivery unit sees a diverse range of patients: referrals from community health clinics, low-income patients, and Harvard faculty members.

20.9%
CESAREAN RATE

4700
ANNUAL DELIVERIES

362
BIRTHS/L&D ROOM



Typical labor and delivery room (left). A preponderance of trash receptacles in each room is disorienting (right) and reinforces the institutional feel of the unit.

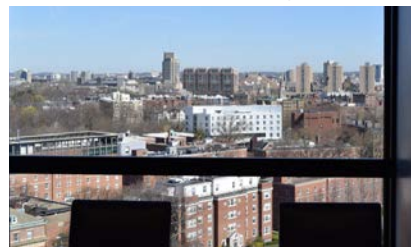


A lack of adequate storage space means corridors are cluttered with medical equipment and supplies.

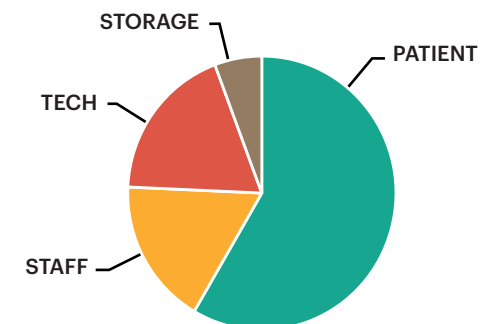


A centralized station is a collaborative work hub where all members of the staff work, monitor patients and carry out shift change reports.

Sweeping views of the Boston cityscape are seen from the staff lounge.



The waiting room is the first stop for patients in labor, who register at the staff welcome desk there. The space lacks warmth and is noticeably outdated.



University Medical Center of Princeton at Plainsboro

COMMUNITY HOSPITAL UNIT

UMC Princeton at Plainsboro is often cited as a success of evidence-based design in healthcare. Labor and delivery moved into the new building in 2012 after a design process heavily engaged with staff, patients and other key stakeholders. The labor and delivery unit evidences many of the novel features that arose from this process.



View from parking lot



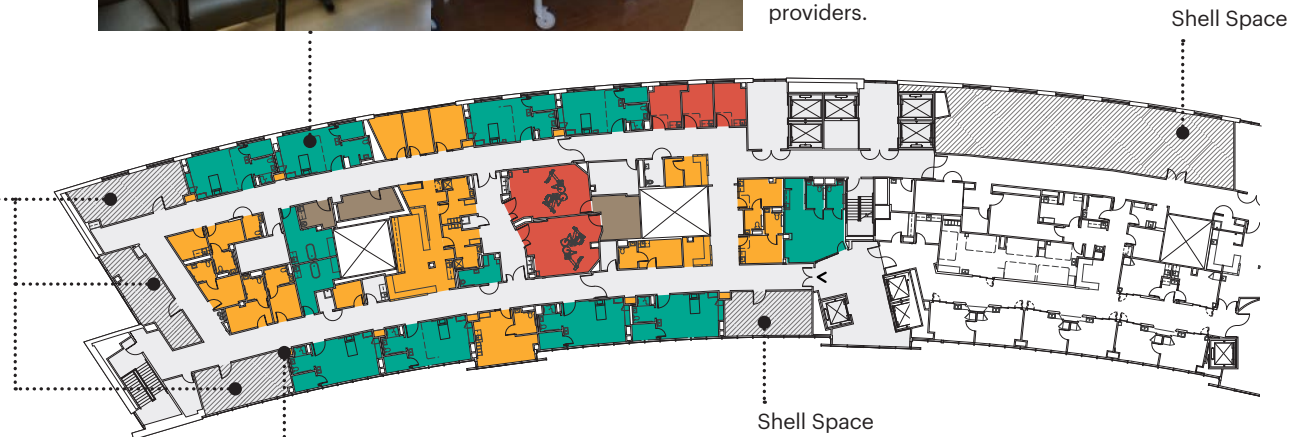
Gorgeously day-lit patient rooms are also “same-handed” to reduce cognitive load on providers and increase efficiencies. The headwalls are meticulously considered and came about through an extensive process of mock-ups that involved actual use with patients and providers.

34.9%
CESAREAN RATE

2000
ANNUAL DELIVERIES

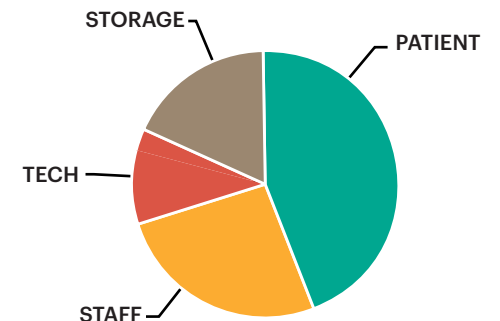
250
BIRTHS/L&D ROOM

Shell Space - the design of the unit included several “shell-spaces” allocated for future growth either in the form of LDR rooms or postpartum rooms.



A very significant challenge for the nursing staff has been adapting to the extended layout of the new hospital. Travel distances across the unit have become a major factor in staffing, often requiring moving patients to increase clustering and reduce staff workload.

Rather than having a single central nursing station, stations are distributed into alcoves in the hallway throughout the unit. This has also been a major adjustment for a nursing staff accustomed to sharing one central, collaborative space.



Tuba City Regional Hospital Tuba City AZ

COMMUNITY HOSPITAL UNIT

This small, desert community hospital is jointly administered by the Indian Health Service and the Navajo Nation. Their patient population is 75% Navajo. Common comorbidities are diabetes and hypertension, risk factors for cesarean delivery. Nurse-midwives manage most labors, with obstetrician backup for higher risk cases and to perform cesarean deliveries when needed.

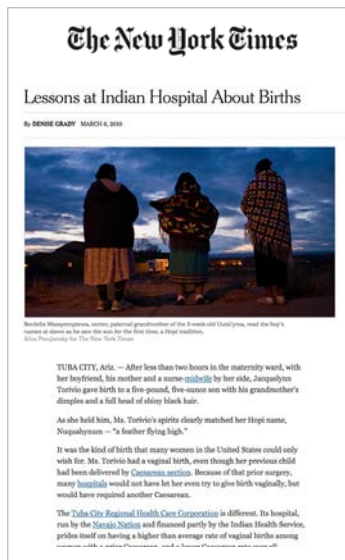


Tuba City Regional Medical Center exterior.

18.0%
CESAREAN RATE

500
ANNUAL DELIVERIES

250
BIRTHS/L&D ROOM



Tuba City Regional Health Care Corporation was featured in a 2010 New York Times article for their success in offering VBAC (vaginal birth after cesarean) to their patients.

Rooms which used to be labor rooms are now triage rooms.

Dedicated breast-feeding + pumping room for staff.

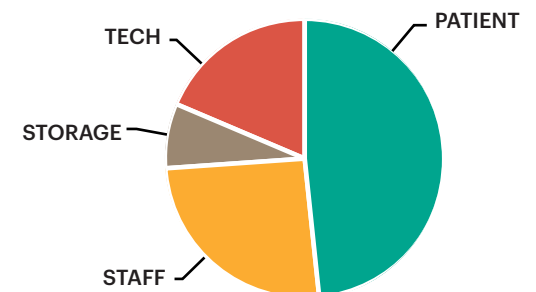


Tuba City has an unusually high ratio of ORs to labor and delivery rooms (2:2). One is primarily a general surgery OR, but can be used for obstetric cases if necessary.

Newborns are rarely found in the nursery, since the hospital is certified as Baby Friendly - these standards require babies to "room in" with their mothers.

Two postpartum rooms are still laid out like an open ward, a relic from the outdated model of obstetric care practiced at this hospital. It's rare to ever need more than two beds in each of these rooms. Equipment ends up stored in here.

Nurses try to treat the two LDRs like LDRPs, in which women labor, deliver, recover and stay for postpartum in a single room.



University of Chicago Medical Center Chicago IL

ACADEMIC HOSPITAL UNIT

Located in Hyde Park, a socio-economically diverse, predominantly African American community, University of Chicago Medical Center sees a large volume of high-risk obstetrics patients. After an extensive, user-engaged design process, the unit anticipates moving to a newly renovated floor in an adjacent building in August of 2016. Their goals are to expand their services for low-risk pregnancies while continuing to serve a high acuity population.

32.4%
CESAREAN RATE

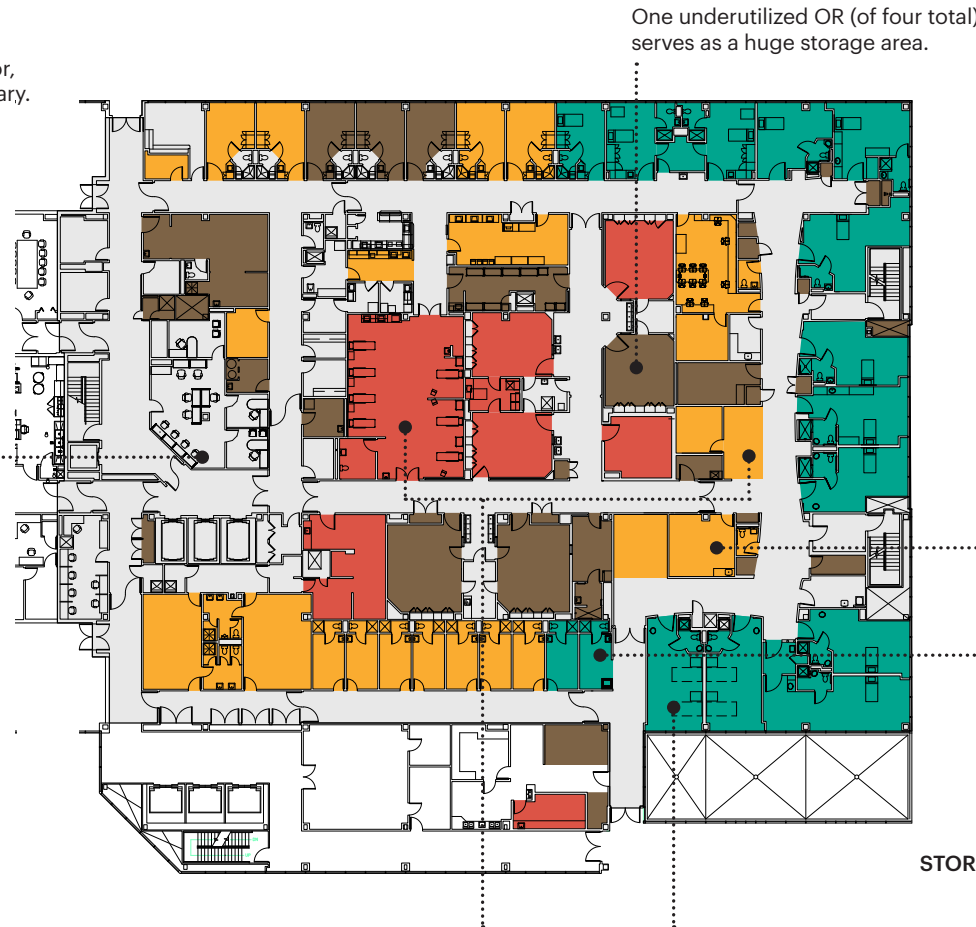
2100
ANNUAL DELIVERIES

233
BIRTHS/L&D ROOM

Although the new unit has a smaller footprint and fewer LDR rooms than the current unit, it will incorporate five antepartum rooms on the L+D floor, which can be used as overflow LDRs when necessary. This placement decreases workload for providers managing multiple patients across services and affords flexibility for labor and delivery.



The "Board Room," is command central for physicians, midwives and residents. Serving as both work room and lounge, the room is visually dominated by monitors with unit census data as well as fetal heart monitor tracings. Nurses and providers work in separate areas of the unit, communicating via mobile phones. A decision was made to preserve this divided model of work space in the new unit.



One underutilized OR (of four total) serves as a huge storage area.

The "staff lounge" is really only for nurses. The new unit will attempt to foster a more collaborative team atmosphere by creating an inclusive lounge.

The unit has recently implemented a new triage system, in which patients are assigned an acuity score immediately on arrival, admitted or, if receiving a low score, sent to a waiting room just outside of the unit. Two call rooms were repurposed to create this waiting space. This system will be preserved in the new unit.

Nurses working in the recovery area are isolated and out-of-rotation in the back of the unit. The new unit co-locates L+D and PACU rooms, so nursing can be shared more readily between areas.

Patients requested individual triage rooms during design meetings - the new unit replaces two multi-patient triage rooms with five private triage rooms.

