Title slide

- Smart Neonatal Phototherapy: IoT-Enabled, Noninvasive Blue/Blue-Green Light Therapy with Real-Time Bilirubin Monitoring [2].
- Tagline: Measure, Treat, Monitor—Closed-loop bilirubin control with mobile dashboards and safety automation [3].

Introduction to the idea

- Integrates a transcutaneous bilirubin sensing array with an adaptive blue/blue-green LED engine that auto-titrates irradiance to improve bilirubin breakdown while enforcing guideline safety limits [2].
- A secure dashboard streams run time, skin surface temperature, and bilirubin trend graphs with patient identifiers to support real-time clinical decisions at bedside or home [3].

Prevalence and reasons

- Newborn jaundice is very common, affecting about 60% of newborns overall, with higher rates among preterm infants due to immature bilirubin clearance [4].
- Contributors include increased red cell breakdown, immature UDP-glucuronyl transferase, hemolysis, bruising, G6PD deficiency, and suboptimal feeding in early life [4].

Risks and what bilirubin is

- Bilirubin is a heme-breakdown pigment that circulates largely unconjugated in neonates; at high levels unbound bilirubin can cross the blood-brain barrier causing bilirubin-induced neurologic dysfunction and kernicterus [5].
- Kernicterus causes permanent outcomes such as cerebral palsy, hearing loss, and gaze abnormalities, necessitating timely monitoring and guideline-aligned therapy [6].

Chemistry of bilirubin and blue light

- Bilirubin's phototherapy action spectrum peaks in the blue/blue-green region near 460–490 nm due to strong absorption and favorable skin optics in vivo [7].

- Phototherapy drives configurational isomerization and structural isomerization to lumirubin, which clears rapidly and underpins the therapeutic decline in serum bilirubin [8].

Introduction to the device

- Uses multiwavelength skin reflectance in a TcB module to estimate subcutaneous bilirubin at the forehead or sternum, compensating hemoglobin and melanin similar to validated TcB meters [9].
- A controller maintains intensive phototherapy in the recommended spectrum while monitoring skin surface temperature and session parameters with encrypted telemetry to a mobile/cloud dashboard [2].

Block diagram of device flow

- Closed-loop sequence: onboarding → reflectance sensing → TcB compute → safety checks → LED intensity set → therapy delivery → logging → encrypted transmission → dashboard visualization → stop criteria [2].

Create a Block diagram: Closed-loop IoT neonatal phototherapy device flow.

Technology used

- Optical sensing with blue/blue-green emitters and a silicon photodiode, applying algorithms to isolate bilirubin from hemoglobin and melanin signals in skin reflectance [10].
- Therapy engine with high-efficacy LEDs in the 460–490 nm band and irradiance verification to meet intensive phototherapy targets defined in neonatal guidance [2].

Sensor design inspiration

- Inspired by pulse-oximeter LED/photodiode modules that use ambient-light rejection and low-noise analog front ends, adapted to reflectance geometry and bilirubin wavelengths rather than transmissive red/IR paths [11].
- Wearable neonatal colorimetry prototypes show stable on-skin bilirubin sensing with PDMS microlenses and black silicone interfaces to reduce stray light and improve signal-to-noise for continuous trends [3].

Create a block diagram of Hardware architecture of the reflectance TcB sensor inspired by pulse-ox optics and validated TcB reflectance methods.

TcB algorithms (named approaches)

- Multiwavelength spectral reflectance (BiliCheck-style): deconvolves bilirubin while compensating hemoglobin and melanin; validated against total serum bilirubin in TcB devices [9].
- Monte Carlo–aided multiple regression for diffuse reflectance: jointly estimates bilirubin, oxy/deoxy-hemoglobin, and melanin from measured spectra using simulated optical transport models [10].
- Sequential inverse algorithm: stepwise estimation of melanin, blood, then bilirubin using wavelength-specific sensitivities derived from Monte Carlo modeling to improve robustness across skin types [10].
- Machine-learning regressors (polynomial regression, SVM, neural nets) trained on reflectance spectra have been reported for newborn jaundice estimation in research settings [10].

Components used

- Emitters: GaN blue/blue-green LEDs centered 460–490 nm for bilirubin targeting plus a green reference channel to model hemoglobin absorption for reflectance corrections [10].
- Detector and coupling: Broadband silicon photodiode with optical baffling and a black silicone interface to suppress ambient and lateral light, following wearable bilirubin sensor practices [3].
- Analog front end: Low-noise transimpedance amplifier with ambient-light cancellation and programmable filtering, inspired by compact biosensor optical AFEs [11].
- Compute and comms: High-resolution ADC feeding an MCU running TcB algorithms with BLE/Wi-Fi telemetry to mobile/cloud dashboards for live trends and alerts [3].
- Safety stack: On-skin IR or contact temperature sensing and session logic to enforce thermal comfort and exposure limits throughout therapy [3].

Research-backed proof for phototherapy

- Intensive phototherapy is defined as irradiance ≥30 μW/cm^2/nm within 430–490 nm delivered to maximal body surface, with routine irradiance checks for efficacy and safety [2].
- Blue-green light near ~480 nm can be as effective or more efficient than ~460 nm blue in vivo due to skin optics, supporting the spectral choices for modern LED systems [12].
- Lumirubin formation and rapid clearance in infants are documented, explaining robust bilirubin declines during properly dosed phototherapy [8].

- TcB methods are accurate and practical for screening and trending across gestational ages when algorithms compensate for pigmentation and measurement conditions [9].

SWOT analysis

- Strengths: Noninvasive TcB with closed-loop dosing, real-time safety feedback, and IoT dashboards that align with neonatal workflows [9].
- Weaknesses: TcB variability across skin tones and the need for irradiance calibration and clinical validation before broad deployment [9].
- Opportunities: Large newborn cohorts and the rise of connected neonatal care and home phototherapy expand adoption potential [2].
- Threats: Established competitors and evolving threshold guidelines require strong validation and compliance strategies [2].

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Create SWOT Analysis : IoT Neonatal Phototherapy Device Positioning

Market opportunity

- Global births remain high annually, and with jaundice affecting the majority of newborns at some level, the serviceable need spans tens of millions of infants per year [13].
- Phototherapy equipment markets are projected to grow through the decade as LED-based devices and connectivity expand in neonatal care settings across regions [14].

Ending like a boss

- This is a single platform that measures, treats, and monitors in one closed loop, making phototherapy smarter, safer, and simpler for high-throughput newborn units and home transitions [2].
- The result is fewer sticks, faster bilirubin control, continuous oversight, and trusted data for clinicians and parents in one interoperable system [3].

Thank you

- Thank you—demo and validation protocol available on request, with a clear path to multicenter studies and regulatory submission for rapid clinical adoption [2].

Tables for your slides

Algorithms used

Algorithm name	Core idea	Notes
Multiwavelength spectral reflectance (BiliCheck-style)	Decompose reflectance to isolate bilirubin with hemoglobin/melanin compensation	Validated against serum bilirubin in TcB meters [9].
Monte Carlo–aided multiple regression	Train regression on simulated/measured spectra to jointly estimate chromophores	Robust to skin optics variation with appropriate priors [10].
Sequential inverse algorithm	Stepwise estimate melanin, blood, then bilirubin from wavelength-specific sensitivities	Improves stability across sites and pigmentation [10].
ML regressors (SVM/NN)	Supervised models on spectra to predict bilirubin	Reported in research; requires diverse training data [10].

Components used

Subsystem	Example part(s)	Role
Blue/blue-green LEDs	460–490 nm GaN LEDs	Target bilirubin action spectrum for sensing and therapy [10].
Reference green LED	~520–540 nm LED	Model hemoglobin absorption for reflectance compensation [10].
Photodiode	Si PIN photodiode	Detect reflected light in visible band with low dark current [3].
Analog front end	Low-noise TIA stage	Convert photocurrent to voltage with ambient-light rejection [11].
ADC + MCU	16–24-bit ADC + MCU	High-resolution sampling and on-device TcB computation [3].
Wireless	BLE/Wi-Fi module	Stream TcB trends, temperature, and session data securely [3].
Temperature sensor	IR/contact skin sensor	Enforce thermal safety and comfort during phototherapy [3].
Optical interface	Black silicone baffle + PDMS lens	Improve coupling, reduce stray light and motion artifacts [3].