



WikiModel:

Using WikiModel to Rapidly Create, Simulate, Fit and Share Mathematical Models

SIMIODE WEBINAR

Systematic Initiative for Modeling Investigations & Opportunities with Differential Equations

April 9, 2024

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Immediate access to application (no download):

<https://www.wikimodel.com>

<https://www.wikimodel.com/about/about-wikimodel>

<https://www.wikimodel.com/about/application-instructions>

The above two links are clickable links on the top right of the WikiModel webpage

Why was WikiModel Created?

High level programming languages and scientific software packages provide maximum flexibility and capability to the user. To simulate models:

- Programming in a particular syntax is required by the user
- A good amount of time is required to code
- The set of differential equations have to be entered in a separate function
- User has to then call that function from an ODE integration function
- User has to start and stop the ODE integration function and change the initial condition for every new discrete input
- To fit models to experimental data, additional code and functions are required
- Typically, experimental data is sparser than model simulated data so additional code is required to pair them up at the right time points for error calculation when fitting the model

WikiModel was invented to help people create, simulate and fit models faster, without being bogged down in their implementation.

Simulation and Identification of Glucose Metabolism Model Parameters in Type 1 Diabetes under Closed Loop

Model fit to individual patient glucose and Insulin data

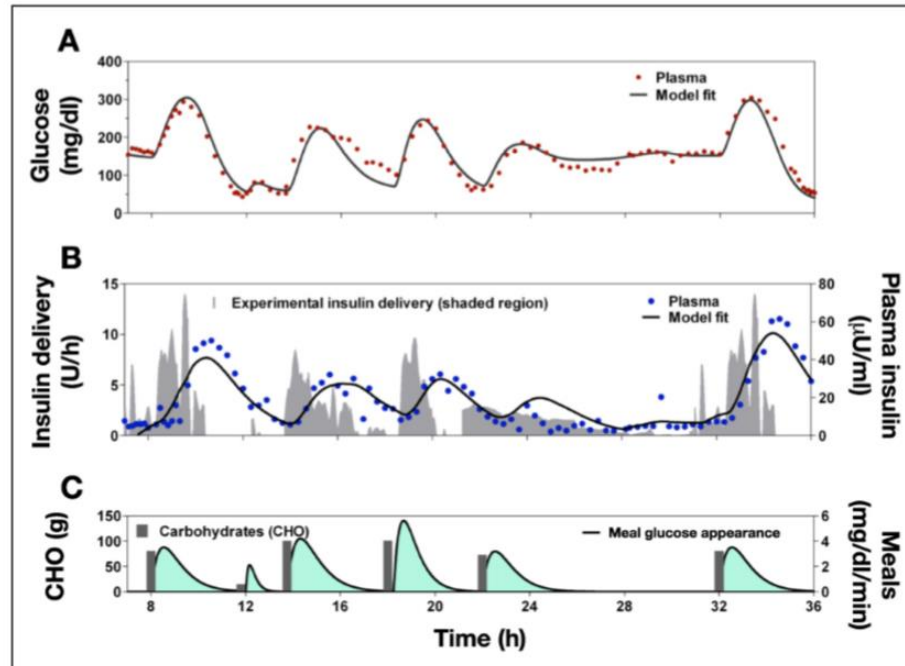


Figure 2. Identification of a subject where no intraday variation was necessary to fit the glucose profile (subject 7). (A) Plasma glucose concentration (solid circles) and model fit (solid curve) showing peak postprandial and nadir glucose for glucose below 80 mg/dl within 15 mg/dl and each occurring with 0.5 h of each other. (B) Proportional-integral-derivative insulin delivery profile (shaded region) and measured insulin concentration⁵ (solid circles) with model insulin profile (solid curve). (C) Carbohydrates intake (bars, left axis) with model [Equation (5)] estimated exogenous glucose appearance (solid curve with shading, right axis).

Average profiles of 10 individual Model fits

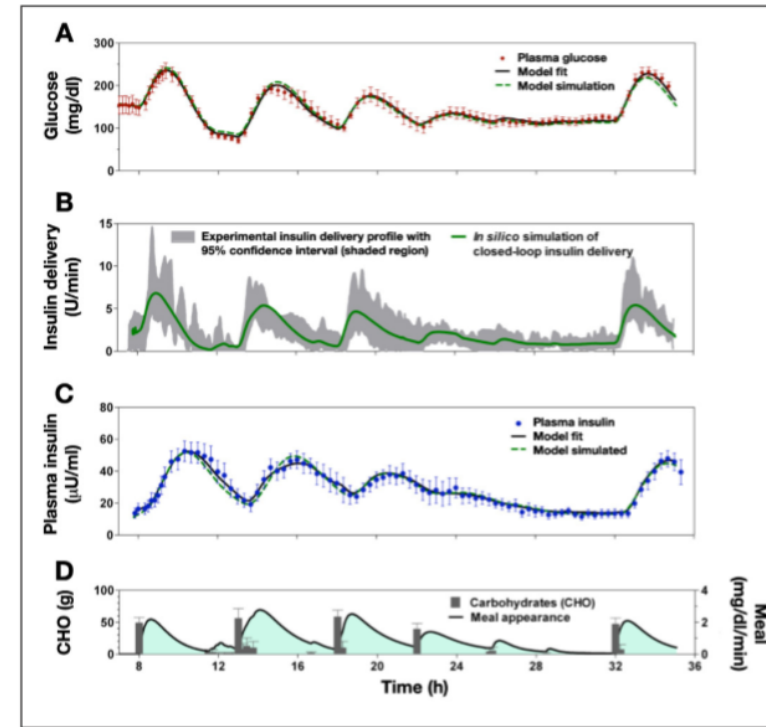


Figure 4. Average fit (solid curve) and simulated (dashed curve) profiles of all 10 subjects. Profiles were fit and simulated individually and then averaged. (A) Plasma glucose (circles \pm standard error), model fit (solid curve; standard error bars not shown) using measured plasma insulin concentrations, and closed-loop model simulation (dashed curve; standard error bars not shown) results. (B) Insulin delivery obtained from the original closed-loop study⁵ with shaded area indicating the 95% confidence interval for the mean, together with the simulated profile (solid curve; standard error bars not shown) using the MVP model [Equations (1)–(5)] and PID algorithm. (C) Plasma insulin (circles \pm standard error) obtained in the original study with model fit using the measured insulin delivery (solid curve; standard error not shown) and simulated values using only the initial conditions at the time closed loop was started (dashed curve; standard error not shown).

Validation of Glucose Metabolism Model against an Independent Dataset

Simulate new control strategy of identified model:

Validate new control strategy against subsequent experimental study:

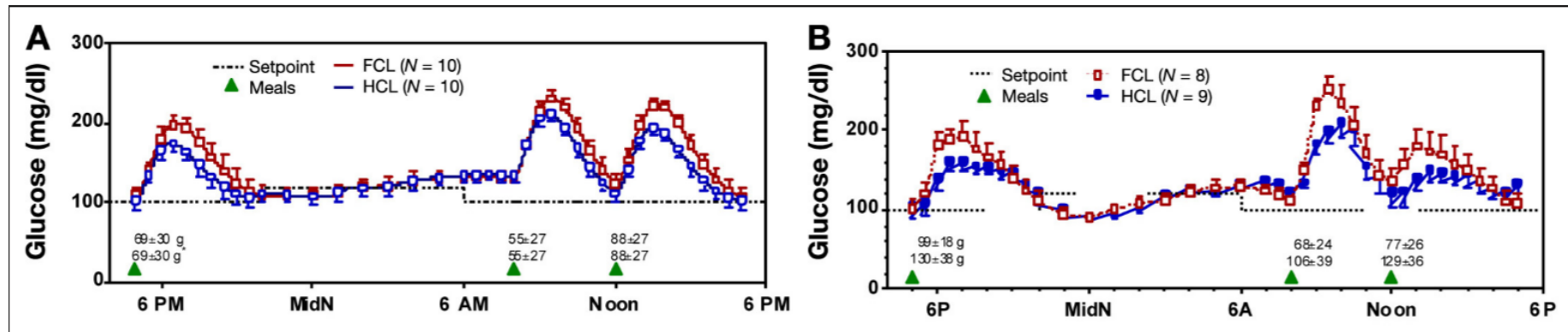


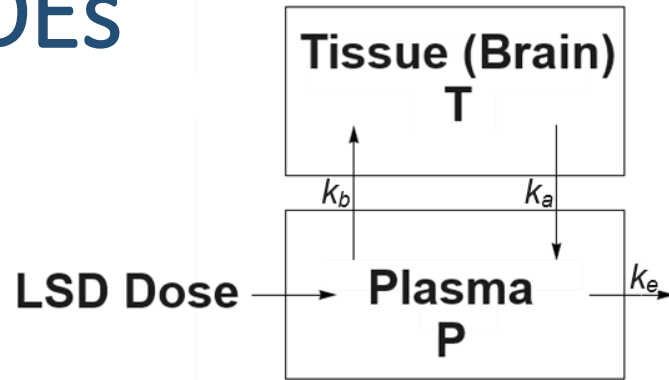
Figure 2. (A) Left panel shows simulation of 24 h closed-loop control in 10 virtual adult subjects using FCL and the same algorithm modified by a meal bolus given by the subject 15 min in advance of a meal (HCL). Each subject was simulated twice with the same meal on both occasions. (B) Right panel shows results from a clinical study performed in pediatric subjects. Different patients ($n = 8$ and 9 for FCL and HCL, respectively) were studied with meals of their choosing (meal size shown in grams).

What is WikiModel?

A web-based software tool for simulating and fitting models

- No programming (enter equations as they appear in a text book)
- No download or installation
 - runs on the cloud via your web browser
 - device/OS agnostic (PC, Mac, tablet, smartphone)
- Handles any number of differential and/or analytic equations
- Simulated results are plotted on the screen
- Seamlessly handles discrete inputs at sparse times
- Seamlessly fits model to experimental data at sparse times:
 - Automatically figures out if linear or non-linear least squares is required
- Models and data are shareable in a library for collaboration and a quick starting point

Implementation of the LSD Pharmacokinetic Model with ODEs



Predefined 2 compartment model

- The building block of a PK model is a compartment where each compartment is defined by a differential equation with drug molecules moving in or out of each compartment at certain rates in (mg/min) or (moles/min):

$$dX/dt = -\left(\sum k_i\right)X + \left(\sum k_j F_j\right)$$

- k_i represents the rate constants leaving X , each represented by an arrow, multiplied by the units of the molecule in compartment X
- k_j represents the rate constants entering X , each of which is multiplied by the units of the molecule in the compartment F_j it is coming from

Model and data reference:

➤ <https://qubeshub.org/community/groups/simiode/publications?id=3333&v=1>

WikiModel simulation/fit link:

➤ [http://www.wikimodel.com/workspace/5081879929683968/Two Compartment LSD Model](http://www.wikimodel.com/workspace/5081879929683968/Two%20Compartment%20LSD%20Model)

Demonstrating the Speed and Ease of Using WikiModel to Solve a Problem

In this session we will

- Register a new user for a WikiModel account:
 - <https://www.wikimodel.com>
- Login (there is no download or installation)
- Create a differential equation model from scratch
- Simulate the model with a set of parameters and plot results
- Enter experimental data
- Fit the model to experimental data to estimate optimal parameters
- Save and share the model

Create the Torricelli model together (Live Demo)

- The Torricelli model describes the change in height of water in a container with a hole in it.
- Using WikiModel, together we will:
 - Create and simulate the model from scratch
 - Fit the model parameters to experimental data
 - Save the workspace (model and data) for public access
- Model and data reference:
 - <https://qubeshub.org/community/groups/simiode/publications?id=3305%5C&v=5>
- WikiModel simulation/fit link (upon completion):
 - <http://www.wikimodel.com/workspace/5081879929683968/Waterfall>

Other Modeling Examples:

models can be found by typing all or part of their name in the search bar

- Predator Prey Model:
[http://www.wikimodel.com/workspace/5081879929683968/Predator Prey](http://www.wikimodel.com/workspace/5081879929683968/Predator%20Prey)
- Projectile Motion with Drag
[http://www.wikimodel.com/workspace/5081879929683968/Marble Projectile With Drag](http://www.wikimodel.com/workspace/5081879929683968/Marble%20Projectile%20With%20Drag)
- Second Order Spring Dashpot System:
[http://www.wikimodel.com/workspace/5081879929683968/Second Order System](http://www.wikimodel.com/workspace/5081879929683968/Second%20Order%20System)
- Three Compartment Bolus Response (Drug Delivery):
[http://www.wikimodel.com/workspace/5081879929683968/Three Compartment Bolus Response](http://www.wikimodel.com/workspace/5081879929683968/Three%20Compartment%20Bolus%20Response)
- Subcutaneous Basal and Bolus Drug Delivery:
[http://www.wikimodel.com/workspace/5081879929683968/Subcutaneous Basal Bolus Insulin](http://www.wikimodel.com/workspace/5081879929683968/Subcutaneous%20Basal%20Bolus%20Insulin)
- Virtual Patient with Type 1 Diabetes
[http://www.wikimodel.com/workspace/5081879929683968/Type1 Diabetes Virtual Patient](http://www.wikimodel.com/workspace/5081879929683968/Type1%20Diabetes%20Virtual%20Patient)
- Model of Covid outbreak:

Replication of Nature, Cell Discovery by Wang, H., Wang, Z., Dong, Y. et al. titled "Phase-adjusted estimation of the number of Coronavirus Disease 2019 cases in Wuhan, China" on 24th of February: <https://www.nature.com/articles/s41421-020-0148-0>

[http://www.wikimodel.com/workspace/5081879929683968/Coronavirus Wuhan A](http://www.wikimodel.com/workspace/5081879929683968/Coronavirus%20Wuhan%20A)

- Hodgkin Huxley Current Clamp:
[http://www.wikimodel.com/workspace/5081879929683968/Hodgkin Huxley Current Clamp](http://www.wikimodel.com/workspace/5081879929683968/Hodgkin%20Huxley%20Current%20Clamp)
- Electrocardiogram:

Replication of McSharry PE, Clifford GD, Tarassenko L, Smith LA. A dynamical model for generating synthetic electrocardiogram signals. IEEE Trans Biomed Eng. 2003 Mar;50(3):289-94: <https://ieeexplore.ieee.org/document/1186732>

<http://www.wikimodel.com/workspace/5081879929683968/Electrocardiogram>

Acknowledgements

- Dr. Brian Winkel
- Ameet Nayak (co-founder of WikiModel)
- Ted Gifford (technical support)
- You all! Please help me increase the adoption of WikiModel!

"I just entered your site, and it looks fantastic. I wish I had a tool like this in the past. Since college, I've never had to seriously use differential equations, and my programming ended with Fortran."

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