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Correction to: An empirical model for educational simulation of cervical dilation in first stage labor

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Continuing work on a recently published empirical model for educational simulation of cervical dilation [1] resulted in identification of errors in the code implementing this model. Numerical values of three parameters and one state variable had to be updated to obtain the original simulation results with corrected code. The errors identified in the original code included incorrect assignment of the value of the parameter that governs the dilation increase due to pressure exerted by the fetus on the cervix, a discrete time step specified in hours with parameters using minutes as a time reference, numerical integration of a static equation, and unnecessary capping of the uterine contraction amplitude. In the MATLAB code listed in the appendix, these errors are corrected. To obtain the originally published simulation results for cervical dilation, three parameter values had to be adjusted, see Table 1.

On closer inspection, it was also found that the value of the parameter AFR_{50} of 7.9 mU/min in [2] was incorrectly assigned to P_6, which is a concentration in mU/mL. In semi-steady state it can be derived from Eqs. (2, 3) of the original paper that the updated value listed in Table 1 corresponds to the concentration in steady state on an infusion of magnitude AFR_{50} for the given pharmacokinetic parameters P_3 and P_4. The evolution of drug mass over time is given by the pharmacokinetic equation, Eq. (4) of the original paper. In semi-steady state, drug mass is proportional to infusion rate. This value is assigned to m (0) in Table 1. Simulation results for cervical dilation using corrected code and adjusted numerical values match the results presented in the original paper in good approximation. The conceptual model and all presented model equations stood up to this additional scrutiny.

The original article can be found online at https://doi.org/10.1186/s41077-018-0068-3.

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Table 1 Original and updated model parameters. See [1] for a detailed description of the individual parameters and references to numerical values

	original value	updated value	units
P_1	0.740		mU/min
P_2	50.0	1.70	mU/(min cm)
P_3	0.0693		1/min
P_4	18,700		mL
P_5	0.500		1/min
P_6	7.90	0.00610	mU/mL
P_7	1.11		dimensionless
P_8	40.0		mm Hg
P_9	40.0		mm Hg
P_{10}	1.00×10^{-3}		cm/min
P_{11}	1.90×10^{-2}	4.00×10^{-4}	cm/mm Hg
m(0)	273	59.0	mU
d(0)	2.0		cm

Appendix

Corrected and verified Matlab code

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%                                                     %%%
%%%          Matlab 2018 code implementation            %%%
%%%              Cervical dilation model                %%%
%%%                                                     %%%
%%%                              Willem van Meurs       %%%
%%%                              Consultant             %%%
%%%                              Dec. 2020              %%%
%%%                                                     %%%
%%% Verified by Lex van Loon and Hans Zwart Jan. 2021   %%%
%%% and by Silvano Gefferie April 2021                  %%%
%%%                                                     %%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% Algorithm implicit in the included comments.
% Symbols as in Gefferie et al. 2018.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
clear
%
% DEFINITION OF SIMULATION TIME
%
% t=(n-1)*T  Discrete time n also serves as Matlab vector index
%
tmin=0.0;           % min
tmax=1050.0;        % min
T=1;                % integration step size (min)
N=round((tmax-tmin)/T)+1;
for n=1:N
    t(n)=(n-1)*T;
end
%
% NUMERICAL VALUES MODEL PARAMETERS
%
P1=0.740;           % mU/min
P2=1.70;            % mU/(min cm)
P3=0.0693;          % 1/min
P4=18700;           % mL
P5=0.500;           % 1/min
P6=0.00610;         % mU/mL
P7=1.11;            % dimensionless
P8=40.0;            % mm Hg
P9=40.0;            % mm Hg
P10=1.00*10^-3;     % cm/min
P11=4.00*10^-4;     % cm/mm Hg
%
% STATE VARIABLE INITIALIZATION
%
m=59.0;             % mU
d=2.00;             % cm
%
% RUN-TIME EQUATIONS
%
for n=1:N
   r=P1+P2*d;
   nm=(1-P3*T)*m+T*r;       % m(n+1)
   c=m/P4;
   s=c^P7/(P6^P7+c^P7);     % sigmoid
   f=P5*s;
   a=P8+P9*s;
   nd=d+T*(P10+P11*f*a);    % d(n+1)
   if nd>10.0               % cap to 10 cm
       nd=10.0;
   end
   output(n)=d;
   m=nm;
   d=nd;
end
%
% GRAPHICAL OUTPUT
%
figure(1)
plot(t,output)
axis([tmin tmax 2 10])
grid on
xlabel('time in min')
ylabel('dilation in cm')
```

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