Supporting Information

S2 Text: Determining parameters from experimental data

The parameter values for $\kappa$, $c_{\text{char}}$, and $\chi_0$ are crucial for fitting to experimentally observed pulse propagation speeds. In our previous work [1], we chose values of $\kappa$ and $c_{\text{char}}$ based on previous measurements [2,3], and therefore only $\chi_0$ was treated as a fitting parameter. While the previous simulations based on these choices reasonably captured the formation and propagation of bacterial pulses observed in experiments, as well as the experimentally-observed dependence of pulse skewness, height, and speed on confinement, the widths of the simulated pulses differed noticeably from the experiments. Because the goal of this present paper is to more closely investigate pulse shape and dynamics, here we develop a new protocol to determine all three parameters $\kappa$, $c_{\text{char}}$, and $\chi_0$ from the experimental data. The experiment is summarized in §2.4 of the main text. The primary dataset we use for fitting (shown in S4 Fig and taken from [1]) is obtained from a late time experimental profile for cells in intermediate confinement (corresponding to §3.1).

Determining $\kappa$. At long times, given that the pulse is nearly unchanging in time, we take $\partial c/\partial t = -v_{\text{pulse}} \partial c/\partial \xi$ and $\partial b/\partial t = -v_{\text{pulse}} \partial b/\partial \xi$. Applying these definitions in Eqs 1–2 and integrating over all space, with the boundary conditions $b(\xi = \infty) = 0$, $c(\xi = \infty) = c_\infty$, $b(\xi = 0) = b_{\text{trailing}}$, and $c(\xi = 0) = 0$ yields the steady-state relationship between nutrient influx into the pulse to the cells being shed at the rear, $\kappa = c_\infty \gamma / b_{\text{trailing}}$. Here, $c_\infty$ was fixed in the experiments to be 10 mM and $\gamma$ was directly measured to be 0.69 h$^{-1}$. Thus, using the $b_{\text{trailing}} = 1.5 \times 10^9$ cells/mL directly obtained from the experimental profile, we obtain $\kappa = 1.3 \times 10^{-12}$ mM (cells/mL)$^{-1}$ s$^{-1}$. This value, which we use for all the simulations reported here, is in excellent agreement with previously reported values [2,3].

Determining $c_{\text{char}}$ and $\chi_0$. Having obtained $\kappa$, we next use the experimental data to determine $c_{\text{char}}$ and $\chi_0$. To do so, we first re-run the simulation of §3.1 but with $c_{\text{char}}$ chosen to be either 1, 5, 10, 50, or 100 $\mu$M—values that span the range reported in previous experiments [2,4]. For each choice of $c_{\text{char}}$, we then determine the value of $\chi_0$ for which the simulation $v_{\text{pulse}}$ best matches the experimental value. Then, having fit $v_{\text{pulse}}$, we pick the value of $c_{\text{char}}$ for which the simulated pulse width best matches the experimental data. Together, this iterative procedure yields the unique combination of $\{c_{\text{char}}, \chi_0\}$ that best matches the experimental long-time pulse speed and width. We thereby obtain $c_{\text{char}} = 10$ $\mu$M and $\chi_0 = 94$ $\mu$m$^2$s$^{-1}$ for cells in intermediate confinement. Because $c_{\text{char}}$ is an intrinsic cellular property, and thus does not depend on confinement, we then use this value of $c_{\text{char}}$ for other simulations testing weak and strong confinement as well. For each of these, we again obtain $\chi_0$ by fitting the long-time $v_{\text{pulse}}$ between simulations and the experiments. We obtain $\chi_0 = 3700$ $\mu$m$^2$s$^{-1}$ and $\chi_0 = 16$ $\mu$m$^2$s$^{-1}$ for weak and strong confinement, respectively.
References


