The functional mechanism of Epidemics and Pandemics - as causally consecutive processes

Ewald Gerth

2019/2020/2021 - epidemic and pandemic
A viral disease that occurred in a limited area of China in 2019 as an epidemic grew into a pandemic in 2020 and spread across the world.
◦ Pandemics are developments with changes and consequences for life and health of the population, for society, economy, culture, education, for international trade and tourism, etc.

The spread of a pandemic is a process –
that is: a process in matter, space and time.
◦ The material, potential and structural basis of the process is a static network in which the somehow stimulated process unfolds dynamically.
◦ In the case of an epidemic/pandemic, the basic of a process is determined by groups of people who live in a society, have contact and exchange.
◦ The epidemic/pandemic goes through the time of occurrence, spread, effect, containment, subsidence – and disappearance.

The process is part of a larger complex.
The epidemic/pandemic is a complex of many processes – not only the transmission of viruses, but also the medical and virological influences and effects on human health and the social environment.
◦ Processes are embedded in an environment of parallel processes with functional exchange.
◦ Processes have a hierarchy. There are higher-level, lower-level and secondary processes that are coupled to one another.
In the case of an epidemic/pandemic, the *sequence of health stages* is – the main *process*, which is determined by *social circumstances as a super-process.* The *transitions* between the stages form the *sub-processes* and the temporally defined effects on the main process are the *secondary processes*.
◦ Processes can be reduced to a main line or extended to the surrounding area.

The study of the functional mechanism requires limiting the reaction system to the main components of the process

Processes are strictly ordered in time.
Time is a one-way street! – There is no *reversal of time* – only a *virtual time mirroring*.
◦ The interchanging of process sections with different conditions is not a “mirroring”.
It leads to different results and is *"non-commutative"*.
◦ The process that takes place in a certain period of time has a history and an after-effect.
◦ The point in time of a change in the process sequence determines the result.

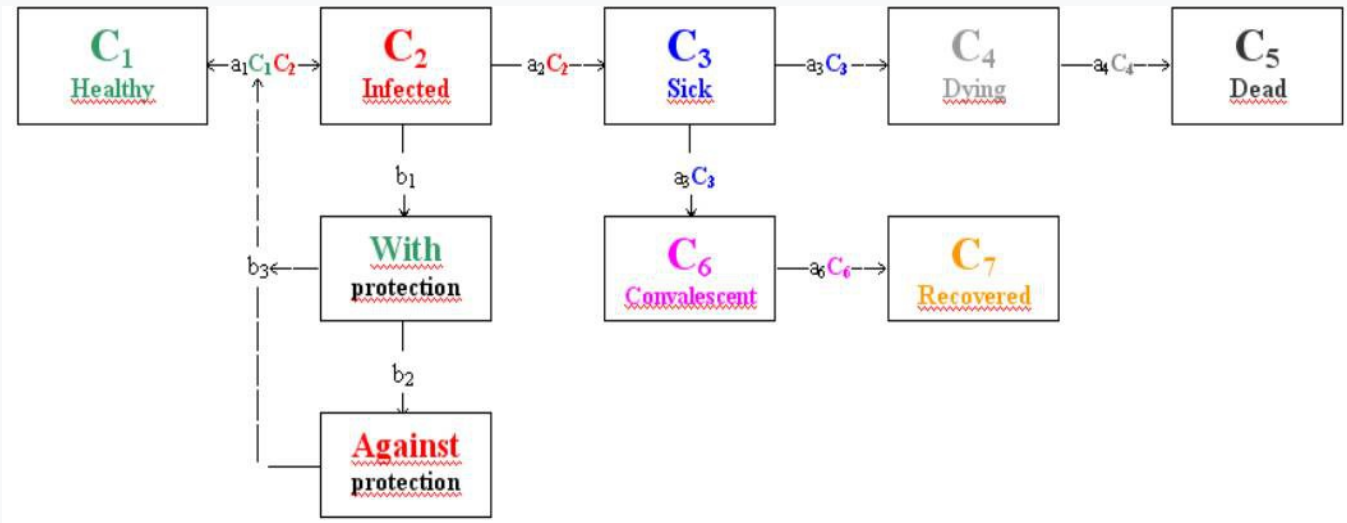
The calculation of the course of processes is carried out with the help of modern computer technology, which enables the illustration, analysis, forecast and tracing of epidemic and pandemic phenomena.

The structure of the epidemic-pandemic reaction system
is determined by the stages a group of people going through in the consequence of infection, disease, therapeutic treatment, and ultimately in the ramification of recovery or death. They form the *basic structure* and thus the *main line* of the *process*.
The transitions between the stages are controlled by *subordinate and side-ordinate processes* with their results, which are summarized as the *transitional variables*.
Side-ordinate *parallel processes* can be coupled with the main and sub-processes at given times and then come into effect.

Subordinate and side-ordinate processes are dealt with separately. However, they can – as in the following the feedback – be included in an extended reaction system.

The causal linkage of the epidemic-pandemic processes
can be divided into a sequence of levels, restricted to the basic functions:
◦ 1. Health - C_1, 2. Infection - C_2, 3. Illness - C_3, 4. Dying or recovery - C_4, 5. Dead or survivors - C_5.
◦ From the third stage of the sick C_3 onwards, the process is divided into dying or convalescent.
◦ The following then applies: C_4 - dying, $C_5 + C_6$ - deceased and convalescent, C_7 – convalescent.
(Note: The designation of the reaction stages is for understanding and does not correspond to medical terminology.)

If these stages are clearly arranged with their mutual relationships, the following scheme results:



In this scheme with 7 functionally connected components, the possible feedback between infected C_2 and healthy C_1 is taken into account, which is caused by the *society-related* reaction to the infection and the *protective measures* initiated and/or by the reaction of those affected to the protective measures and the *resistance* that ensues comes about.

The *feedback* from C_2 to C_1 takes place as a *sub-process* in a secondary process loop via the levels ***With Protection*** and *Against* ***Protection***, which are sub-groups of component C_2. In the system list, they are listed as components C_8 and C_9.

The components and coefficients of the stage transitions
between the stages are determined by the sizes of the components C_1 to C_7 and by the *coefficients* of the couplings; these are the coefficients a_1 to a_6 and b_1 to b_3.
The coefficients a_1, a_2, a_3, a_4, a_5, and a_6 are the factors of the driving transitions; b_1 and b_2 control the feedback.
The coefficients can be adapted to the course of the real process by variation.
The coefficients include the results of the sub-processes of transmission and shielding of the infection, control by testing, virus reproduction and spread, medical treatment related to immunity, and mortality, etc.

According to the above flow diagram of the course of the reaction,
the step transitions relate to the following real phenomena and processes:
$C_1 \leftrightarrow C_2$: $a_1C_1C_2$: mutual transition; promoted by the type and effectiveness of the infection dynamics; obstructed by distance, mask, barrier, cleaning, ventilation, vaccination
$C_2 \rightarrow C_3$: a_2C_2: transition of the proportion of infected people who become ill
$C_3 \rightarrow C_4$: a_3C_3: transition of the proportion of sick people at risk of life
$C_4 \rightarrow C_5$: a_4C_4: Percentage of seriously ill people who have died
$C_3 \rightarrow C_6$: a_5C_3: transition of the proportion of sick people with healing
$C_6 \rightarrow C_7$: a_6C_6: Proportion of recovered sick people
$C_1 \leftarrow C_2$: $b_1b_3C_2$: feedback via $b_2 \rightarrow b_3$ with infection protection and
$b_2b_3C_2$: Feedback via $b_1 \leftarrow b_2 \leftarrow b_3$ with cancellation of the protection against infection

According to this, the coefficients can be given the following meanings:
a_1 - infection coefficient
a_2 - disease coefficient
a_3 - fatally ill coefficient
a_4 - deceased coefficient
a_5 - healing coefficient
a_6 - recovery coefficient
b_1 - feedback coefficient
b_2 - protection coefficient
b_3 – resistance coefficient

Setup of the system of reaction equations.
During the process, the proportions of the proportions of the components C_1 ... C_7 contained in the individual stages of the reaction system are changed. The change in C occurring in the difference d of the time t, i.e. in the time segment dt, and the amount of component C, i.e. dC, is called
reaction speed of C:
$V = \mathrm{d}C/\mathrm{d}t$.
Likewise, the products of the components C and the coefficients a are *reaction speeds*:
$V = aC$.

When the reaction passes from one stage to the next, $V = aC$ is transferred.
This value is subtracted from the previous stage and added to the next stage.

The following equations are taken from the above reaction scheme for all step transitions:

$$\mathrm{d}C_1/\mathrm{d}t = -a_1{*}C_1{*}C_2$$
$$\mathrm{d}C_2/\mathrm{d}t = a_1{*}C_1{*}C_2 - a_2{*}C_2$$
$$\mathrm{d}C_3/\mathrm{d}t = a_2{*}C_2 - a_3{*}C_3 - a_5{*}C_3$$
$$\mathrm{d}C_4/\mathrm{d}t = a_3{*}C_3 - a_4{*}C_4$$
$$\mathrm{d}C_5/\mathrm{d}t = a_4{*}C_4$$
$$\mathrm{d}C_6/\mathrm{d}t = a_5{*}C_3 - a_6{*}C_6$$
$$\mathrm{d}C_7/\mathrm{d}t = a_6{*}C_6$$
$$\mathrm{d}C_8/\mathrm{d}t = b_1{*}C_2 - b_2{*}C_8$$
$$\mathrm{d}C_9/\mathrm{d}t = b_2{*}C_8 - b_3{*}C_9$$

This system of equations for the reaction rates can be solved as a whole and calculated numerically with given data of the components and coefficients.

Notes on the theory and mathematical treatment of processes - see: www.ewald-gerth.de/reaction-tensors.htm

A computer program as a tool

A special computer program is used to analyze the process.
The curves are entered individually in the diagram and adapted to the coordinate system with colored marking.
Such a program for calculating the process with a clear representation of the curve is informative and useful in many ways:

- for analysis and recognition of the functional relationships,
- for an overview of the requirements, dependencies and consequences,
- for adapting the transition coefficients to the real process,
- for estimations and predictions about the expected course,
- for the application of measures to specifically influence reality,
- for experiment, planning and warning.

Initial and accompanying conditions of process calculations

The calculation of a process is based on the initial distribution of the quantities of the components on the stages of the causal chain. During the process, the quantity distribution is changed by internal and external influences. A halt command is provided in the computer program to accompany the course of the process, which allows the values of components and coefficients to be changed. After restarting, the calculation continues with the new variables. The course of the process can also be continuously controlled with *time functions* that are underlaid as a factor for the transition coefficients. In this way, *periodic influences* (seasons, weeks, days) and *temporal impulses* can be considered.
Notes on the emergence of pandemic waves – see: www.ewald-gerth.de/pandemic-waves.htm

Calculation and graphic illustration of the course of processes

In the following, examples of processes with special reference to the pandemic are presented and discussed. The series will be continuously supplemented.
The following demonstration examples relate to the initial conditions:

- $C_1 = 100$ and $C_2 = 1$ – that means: A group of 100 healthy people is infected by someone who is already sick, who then infect each other.
- Coefficients: The transition sizes a_1 to a_6 are chosen in such a way that the known courses of the pandemic are reproduced in a qualitatively correct manner.

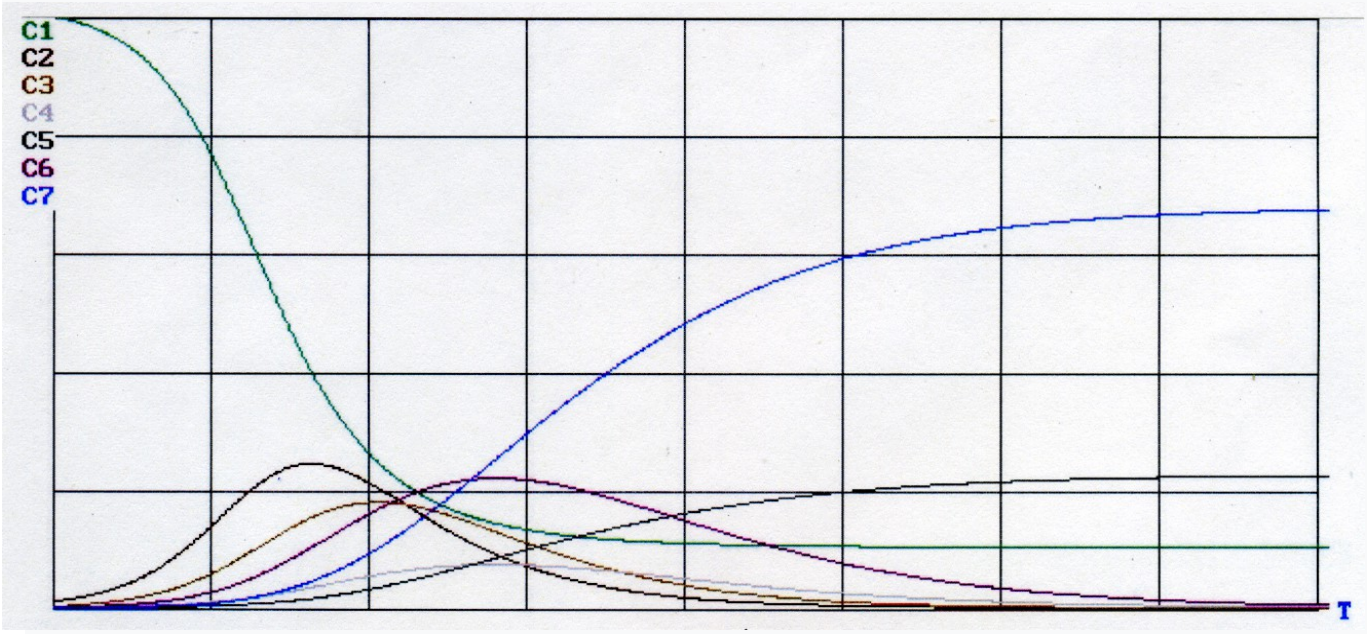


Figure 1 **Straight-line course of the process** (without secondary and sub-processes).
The green curve C_1 shows the decrease in the number of those who are still healthy up to a final value, which is determined by the transition from infected C_2 (red) to disease state C_3 (brown).

A phase shift is characteristic here, since the number of sick people still increases when the number of infected people has already exceeded the maximum. All transition sets are rates, i.e., they subside again after passing through a maximum.
The gray curve indicates the rate of dying C_4, which is proportional to the purple curve of the rate of convalescent C_6, since both rates together in their ratio to each other (here 1: 3) have left the condition of the sick. Both rates are phase-shifted compared to those with C_3 because death or recovery are succeeding to the disease. Finally, the dying C_4 (gray) accumulate in the number of the deceased C_5 (black). The number of convalescent C_6 can also be collected together with the convalescent C_7 (blue). Both groups split up according to the disease C_3 (here 1: 3) and together with the non-sick (green - end of the curve) result in the initial set of healthy persons (green).

It is sometimes difficult to tell the curves apart in the diagram. The computer program used, however, allows the curves to be drawn repeatedly with the previously calculated and stored data, fitting them into the coordinate system by stretching and shifting. Individual curves of particular interest can be picked out and redesignated with colors. Some curves – e.g. the number of people recovering C_6 and those who have recovered C_7 – are of less interest because they are not measured in public statistics. One is only interested in the number of deceased C_5. In this way, the diagrams can be simplified and made clearer.

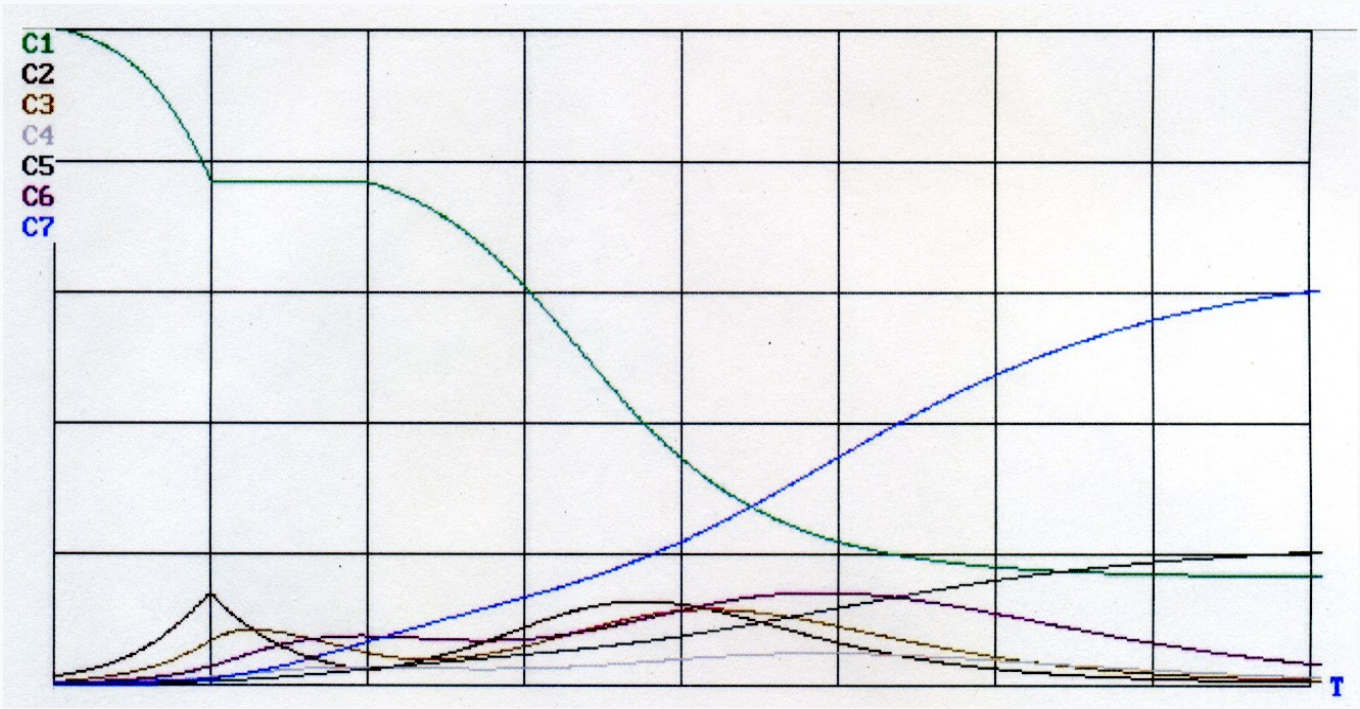
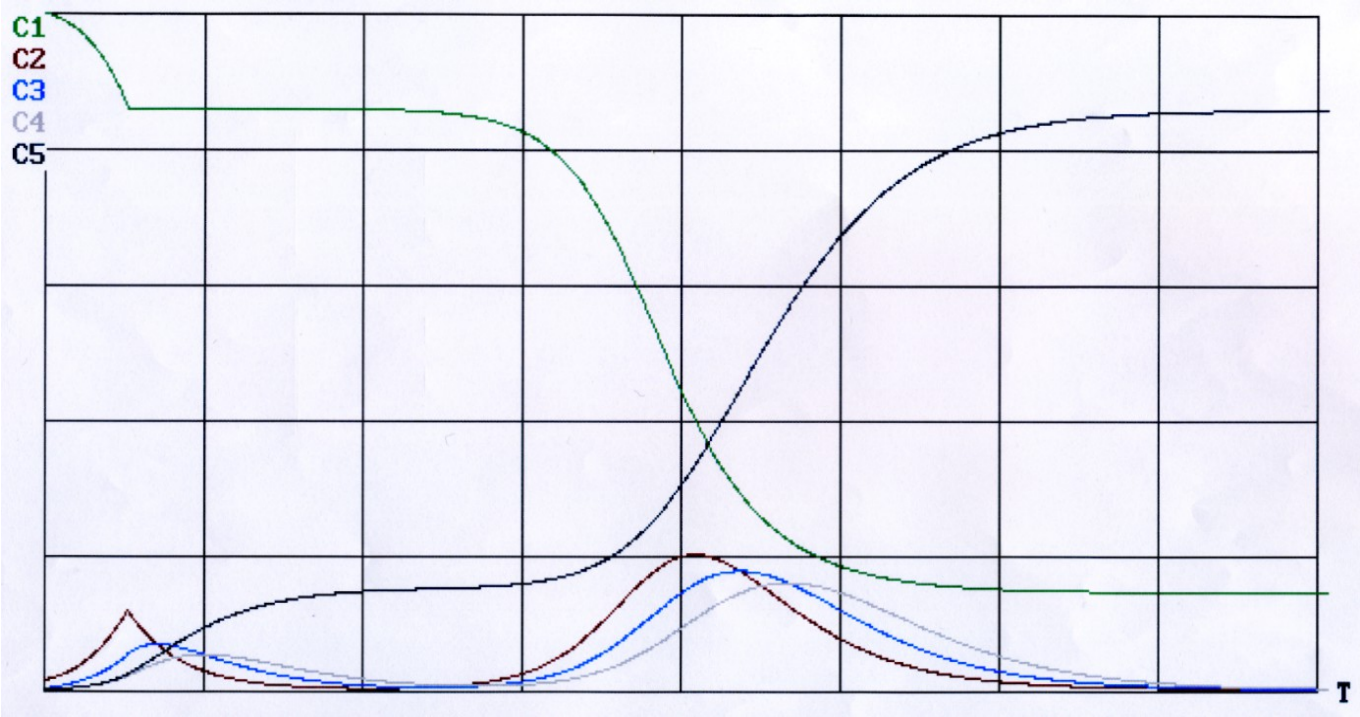


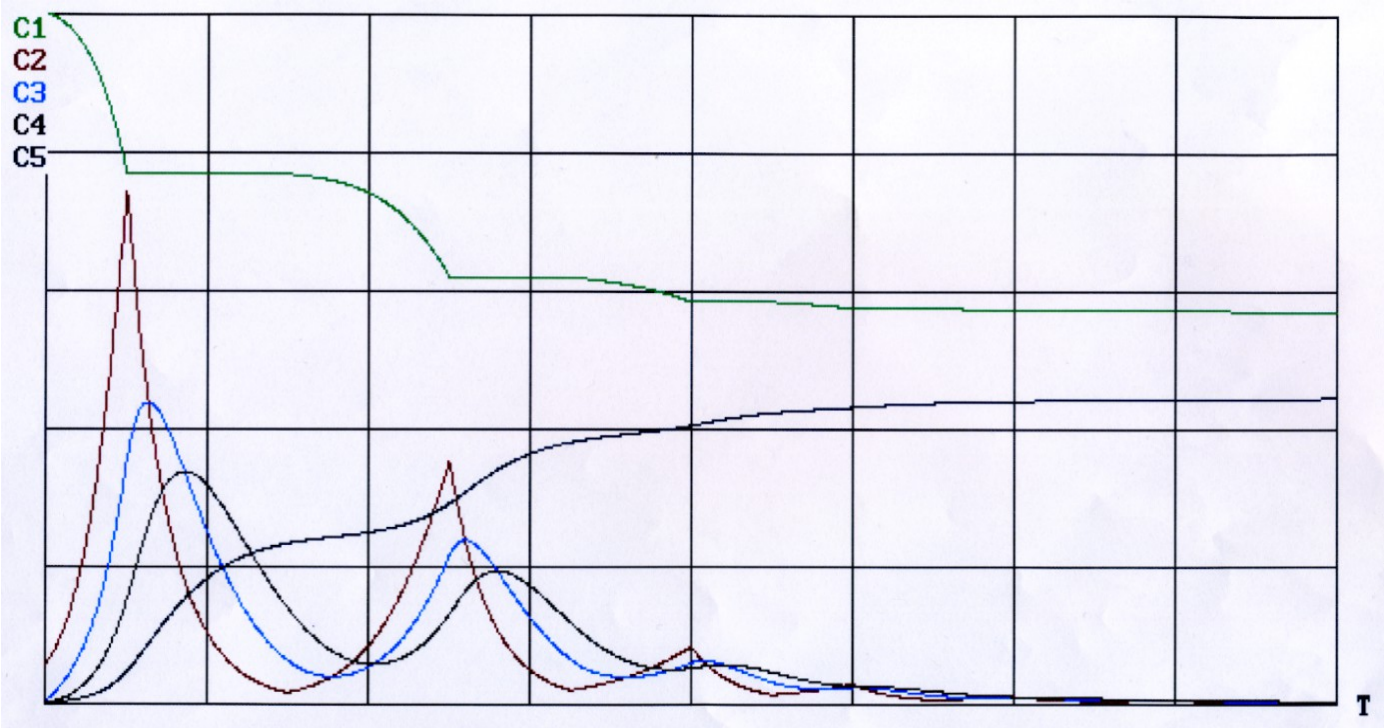
Fig. 2 **Temporary interruption of the protective** measures (as a public reaction) with the same color coding of the curves with initial conditions and coefficients as in Fig. 1.
The coefficient a_1 was only set to zero in the second period of time. This is a reaction of the public to the increasing number of infections and corresponds to a sudden and radical application of protective measures (distance, mask, lockdown, ban on gathering). The feedback is triggered by the increase in C_2. The reacion follows from a transfer function (e.g. distance rule – diffusion, Gaussian error spread function). In the program $a_1 = 0$ was set. The end of the interruption is also an act of feedback, because resistance from a broader public means that all temporary protective measures are suspended again. The process continues – but under different conditions than in Figure 1. The red curve of infected C_2 shows a peak due to the introduction of protective measures and the associated sudden termination of the infection and then subsides to a minimum – but then, after suspending the protective measures and resuming the infection, rise again. This is the **second wave**, which, depending on the length of the interruption and the resumption of the infection process, can be smaller or larger than the **first wave**. Then there follow the rates of stages C_3, C_4, and C_6 with phase delays.

Fig. 3 **Further extension of the interruption of the protective measures**



With the earlier onset and the extension of the interruption of the protective measures, the second wave gains strength compared to the first wave, but then subsides again. The phase lag of the rates of C_2, C_3, and C_4 can be clearly seen here. For a better overview, only the curves of the components of the reaction chain C_1 to C_5 are shown. Here, C_5 means the sum of those who have been treated $C_5 + C_7$, i.e. those who have recovered and who have died together. Both curves (C_5 and C_7) run proportionally on the ordinate.

Fig. 4 **Periodic interruption of protective measures**



If one continues the sequence of interruptions in the protective measures, the result is a periodic continuation of the incidence and thus also of the subsequent phases of the sick and the then dying/convalescent.

Excitation of oscillations by feedback.

The increasing shortening of the period length also occurs with the *automatically regulated feedback*.
The secondary process of the feedback loop (see reaction scheme, – first picture, $C_2 \rightarrow b_1 \rightarrow b_2 \rightarrow b_3 \rightarrow C_1$) is used to scan the size of the infection rate and, by means of the protective measures (distance, mask), according to a probability function that determines the reduction in infection (Gaussian error scattering, filtering, diffusion) it is transferred to the infection coefficient a_1.
In any case, it is a ***self-excited oscillation system*** that works as the result of the phase-shifted alternation of defense against and admittance to the infection. There is no sinusoidal oscillation like a pendulum, but an ***impact oscillation*** like a dropped ball or a trampoline, whereby the amplitudes and the period lengths become smaller under the effect of the loss of energy and substance as well as the damping from wave to wave. While maintaining the conditions of the oscillation system there is not only the **second wave** but also a *third, fourth,* etc. The waves finally die out if they are not excited by new stimuli from outside.
Notes on the occurrence of epidemic/pandemic oscillations – see: www.ewald-gerth.de/pandemic-waves.htm

Vibrations (time waves) can be stimulated in various ways:
1. The addition of healthy C_1 and/or infected C_2 people,
2. crowds of people clustered together in a small space,
3. changes in the transmission conditions due to external circumstances (impulses, temperature, climate, season of the year, new mutations of the viruses),
4. sociopolitical circumstances and administrative measures,
5. transfers from other areas and infection sources.

Permanent vibrations

If the influences occur periodically in phase, a so-called yo-yo effect results – that is, an intensified and steady vibration occurs with continued repetition of the waves. With the knowledge and predictability of the function, however, the oscillation can be specifically dampened and finally eliminated.
The main purpose of damping the vibrations are protective measures (distance, mask, cleaning, ventilation), but then also combating the virus population by vaccination with immunization of as large a proportion of the population as possible, as this eliminates the process-like replication centers of the viruses.

Conclusions from the occurrence of epidemic-pandemic time waves:

* The infection coefficient a_1 must be kept as low as possible! For this purpose, the protective measures are used, which are not to be used arbitrarily but according to circumstances and needs.
* The point in time at which protective measures against the infection are introduced is decisive for the effect – the earlier the better!
* Stopping the infection process after the protective measures have taken place does not mean the all-clear! - Those previously infected can become ill with a phase delay and progress further in the process of the disease.
* The decrease in incidences after the introduction of the protective measures is not a signal for superfluity or even a license to eliminate them! – The oscillation potential is still there – like a water wave that sloshes up again after the wave trough.
* After the protective measures have been suspended, the infection process begins again – based on the latest status. – So even in the low phase of the infection, the protective measures should be continued – with careful relief. Because: The decrease in infection is a consequence of the protective measures - not the other way around!
* The pandemic does not end with the infection and its containment but continues with phase delays in the process of illness, therapy and recovery or death.
* With the transition variables determined from the incidence data, predictions can be made about the further course of the process and precautions can be taken for protective measures, therapies for the sick and social consequences.

The elaboration continues.
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