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The Probabilistic SIR Model (PSIR) in the Pandemic Process

Project Management in Prevention and Support

Springer Vieweg

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What You Can Take from This *essential*

- The SIR - Model is used as a Basis for a Probabilistic Model
- preventive, treatment and aftercare measures should be based on a Probabilistic Model

Foreword

According to all the insights experienced in the COVID process, one essential remains:

“The virus remains a constant companion”

In contrast to regularly occurring infection processes, a COVID infection takes a different course. This is characterized by a dynamic that deviates from conventional, well-known processes in that the originators of the processes change their identity. It is therefore necessary to take measures that make early action possible. Identifying the type of virus can help prevent a large proportion of illnesses. But all the necessities should be prepared for this. However, this also requires management of the “waves before the waves”, which is considered in this paper using a probabilistic SIR model.

Edward Brown

Acknowledgements

I hereby thank Mr. Edward Brown, United States Department of Health and Human Services warmly for his idea of supplementing the SIR model with a probability density Eqb as a replacement for the component I(t) of the differential equation.

This work was created with the excellent software Microsoft Office, the translations into English were mainly done by Google translator with subsequent fine corrections.

Contents

1 Occasion, Derived from a Letter to the Editor

The pandemic process was perceived differently by the population. The fears and behavior of those who could not deal with the permanent impassability were correspondingly differentiated.

Replies to a letter to the editor may help to support the avoidance process through behavioral patterns.

"What's going on in Germany and in the world has been pure madness since day one, the beginning of the corona infection process"—which we can counter if:

- everyone act quickly and consistently against it,
- all renounce their own freedom and follow the duty to protect others from infection.

"It makes you unhappy and depressing when a wave of infections affects the population for a very long time have to endure"—which we may encounter when:

- we can identify the type of infection at an early stage,
- we can develop a defense in time,
- can communicate the resistance to the human organism,
- the observation of the resistance suggests that it is successful.

"People who have been vaccinated still have to have themselves tested daily at work"—which we may encounter if:

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- we follow all the rules that are effective so that subsequent infections are avoided.

Because the virus family called COVID has a lot in common with our behavior, they acts as follows:

“Discover the Possibilities”
“Seize the Opportunities”
“Act on Success”

“We have to accept the risks that result from being vaccinated”—which we may encounter if:

- we relate the ratio of my risk to our risk, corresponding to Motto;

“One for all, all for one”,

- the “I” is dispensed with and instead the “we” becomes more important,
- is considered in reasonable proportion: the ratio of risk to the number of

Side effects to the number of successfully avoiding the spread of the virus.

“The intensive care units lack staff capacities”—whose adaptation we can meet if:

- from observing the way of duplication in other countries we learn and follow the findings of the observers (personnel requirements, bed capacities),
- Assign higher—contractually secured—payment to the work of the nurses and thereby achieve higher attractiveness for taking up the profession.

“divide society with fear”—which we encounter when:

- the majority of the population is acting collectively, the minority of those is acting for themselves confronting to those acting alone,
- the majority through example and survival—the minority through successful action convinced,
- Politics through precautionary, early, careful, nationwide guidelines for security in the instructions for action.

"Should vaccination become compulsory, it would be the end of democracy, because the medication is still not sufficiently tested"—which we may encounter if:

- we have already observed how successful end-to-end testing and adaptation to the results are uccessful/unsuccessful in other countries,
- we accept that a democracy—i.e. the rule of the people—always depends on their own joint actions.
- again applies "One for all, all for one"

"It is known that manufacturer-dependent vaccines are only effective for 4 to 7 months and patients will not become healthier through subsequent vaccinations". we can do that from the current perspective:

- not yet counteracted with drugs, they are under development,
- react only with adapted additional vaccinations for the mutable virus and its family, because for this the principle applies:
  "Discover the Possibilities"
  "Seize the Opportunities"
  "Act on success"

"The Swedes didn't have a lockdown and they haven't died out either"—the extinction of the in.

The community living in the Federal Republic can be counteracted by:

- the duration of the infection process is used to produce offspring that the knowledge and the success associated with it or the ignorance or that with it associated failure—value the previous generation and act accordingly,
- the current population of our so precious homeland to the instructions of those who know follows—this includes all those who create knowledge, who transfer their knowledge to schools carry, in the crafts, in the industry, in the universities of all departments,
- Account for the fact check on Sweden since the start of the wave in Sweden bear in mind the fact check of the USA, that of all European states, and, if a comparison is to be used, to the states that were just not in a position to do so to provide vaccines to the population.

„People immunize themselves by contacting the pathogen.”—unless:

- they avoid contact with pathogens,
- their immune defense does not know the pathogen and also not its behavior in the self-replication in the various organs, (note: when the first European sailors settled South America around 1500, they created a deadly cold virus pandemic there).
- they do not follow their order to multiply. For this there is one of cognition following difference to influenza viruses: COVID viruses mutate and follow a quite human sequence, as previously listed:
  “Discover the Possibilities”
  “Seize the Opportunities”
  “Act on Success”

“The government is narrow-minded or calculating, we don’t know the real background.”—to that we can counteract this by:

- by own, prudent behavior of the spread of the virus family and their compulsion to spread block the way into our organism,
- the spread compulsion of the virus family spread through the body’s own enable resistance training,
- prevent the spread of the virus family by immediately recognizing them as enemies.

“People are fed up with things going on like this.” We will work towards “going on like this” act in:

- we counter exactly what the virus family does:
  “Discover the Possibilities”
  “Seize the Opportunities”
  “Act on Success”

… and with the help of those who create knowledge, the helmsmen, the virologists, everyone nurses and doctors, general practitioners, vaccination centers, parishes, artists, schools, kindergartens, Day care centers, companies, organizers… and with ourselves!

A complete end to the pandemic is not in sight. We released the virus into the wild and it is up to the population as a whole on this planet to spread the compulsion to put a stop to the virus family—and that through:

- Renunciation of one's own freedom in favor of the duty to protect others, in particular those who, as a result of the high number of infected COVID unvaccinated by a Intensive care bed have to fight and the associated "godlike decision" of doctors,which thus over death or life of one or other areas. Our duty as the Elder, Wise, Knowing is the obligation to comply of all measures to break the current "wave" and a "5. Wave" for the benefit of our children and to avoid children's children.

Here is quoted: United States Department of Health and Human Services, Edward G. Brown:

> "Early treatment, prophylactic measures and better testing are among the most important things to do at the onset of an outbreak. In addition, of course, the new virus needs to be identified and profiled, so all these things need to happen as soon as possible. In my view, vaccination should be the last thing and only after proper efficacy and safety studies there shouldn't be anything rushed."

2 Objectives

Courses of infection can be described with the SIR model, a set of three differential equations. A method is to be presented which supports the model with a probabilistic component in such a way that part of the equation system is replaced by a probability density. This includes the application of sample analysis with the aim of being able to draw conclusions about the population from the results obtained, which reveals the character of the process. This requires data collection that indicates the characteristic properties of a process when analyzed by obtaining statistical indicators from the sample numbers, which reveal their values in frequency tables or graphs. These key figures, also called parameters, are the basis for a theoretical consideration of the future of a process, which is called the density function. By far the most frequently used function is the Gaussian normal distribution when it comes to describing the scatter of measured values, i.e. those measured values that provide infection surveys.

The following article deals with the use of a density function Eqb (Fig. 2.1b), whose parameter values are generated from test data as a substitute for the course of I(t) of the number of infectious individuals in a SIR model, (Fig. 2.1a).

The following steps are carried out, which can be found in the following chapters:

1. The SIR model remains the basis for a future modified model.
2. The "infection curve" I(t) is replaced by the Eqb—density function.
3. The basis for the Eqb—density are the test series results as a data record of the frequency of the I(t) from which the parameters are derived that influence the "shaping" of the function.
4. The test data are significantly influenced by the day of the week on which the surveys took place. Therefore, there is a "graphical difference" between the

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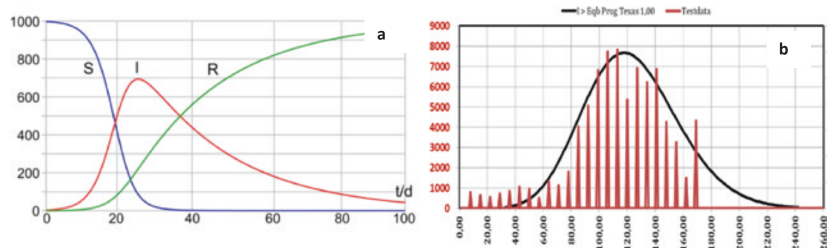

Fig. 2.1 **a** https://upload.wikimedia.org/wikipedia/commons/b/bd/SIR-Modell.svg **b** Frequency distribution and density Eqb

values of the density function and the frequency data, which can be adjusted by applying Gauss's "least squares" method to derive the most plausible parameters with the choice of a day of the week, which then come into play in the density.

5. Since the frequency distribution is linked to the quantities in connection with the time course, a joint statement can be concluded, so that the course of the density values from Eqb can be used to draw conclusions about the future development of the frequency distribution along the time scale.
6. Since the frequencies "wave" over time depending on the behavior of the population, it is important to determine when the slope of the frequency distribution increases or decreases between time intervals, because then it is time to reset the starting point of observation and analysis.
7. From an interval—logarithm, conclusions can be drawn about the exponent of the function and thus about the future development of the frequency distribution and thus about the course of future processes.
8. A shift in the summation of the Eqb before the start of the process—before the start of an infection process—may contribute to recognizing how a population could have been prepared before the influence of an infection event.
9. Using the above steps means that measures can be planned at an early stage.

The SIR models described so far and their derivatives are based on the relationship of a hypothetical connection between differential functions.

The replacement of the connection between I (infected), S (infectable) and R (recovered) by S' = S (− β I), for b as contagion factor let S' = S (− β p (I)), for p der percentage from the density (see also: Kermack-McKendrick Model—from Wolfram MathWorld).

This work includes proposals how the existing SIR model can be applied as a probabilistic PSIR model using the Equibalancedistribution—a new probability density that accounts for skewness and kurtosis.

SIR Model as a Basis for a Probabilistic Model

3

3.1 Conditions of the Model

If we assume an infection, the following quantity terms (quantity term for populations). Used:

- amount of infectious, susceptible (S), engl. succesibles
- Amount of infected, infectious (I), engl. infectious
- Amount of Recovered Retained (R) recovered

The SIR model is derived from these populations. It is based on the context and assumption that the infection process occurs over a period of time such that:

- The number of infected (I) affects the number of infected (S) and recovered (R).

This is expressed in the following graphic, (Fig. 3.1).

The following chapter shows that test data collection and subsequent statistical-probabilistic calculations always come "very close" to a "true" course of an infection process when frequency density and function values indicate a match via a regression analysis. Then a future course can be derived from this and it can thus provide the basis for planning preventive measures. It is shown that there are fundamental differences between

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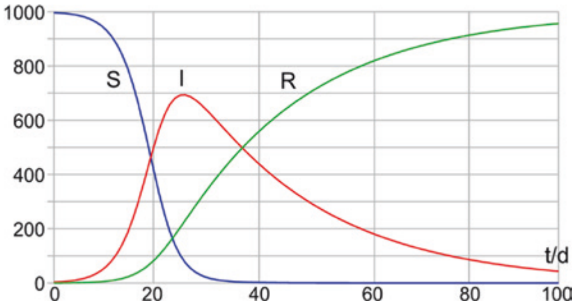

Fig. 3.1 SIR Model

- a mathematical theorem that is valid "forever".
- a statistical-probabilistic statement that always requires an examination of the agreement between theory and practice.

The following chapter is listed for this.

3.2 Probability/Mathematical Theorem

Probabilistics can make statements to determine the future occurrence of events that are statistically collected. This requires measurements that provide the basis for the starting conditions of the probabilistics as well as for a continuous forecast. If scientists try to find the truth—in the sense of—100 percent certainty—they will fail. There will always be a difference between mathematical and statistical truth. A mathematical truth is defined as a mathematical proof. A statistical truth, for which no proof can ever be found in a mathematical point of view, applies only to comparing samples of a set of experimental values with a theoretical density function, which always depends on the set of experiments that have been collected. So the answer is ultimately: On the one hand, one acts with the strength of a deterministic algorithm in the mathematical sense, on the other hand, a data set is evaluated in the statistical sense using a density distribution such as the density distribution to approximate a truth. In connection with the previous statements, it is pointed out that this work only makes statistical-probabilistic statements; influences from other specialist areas are not taken into

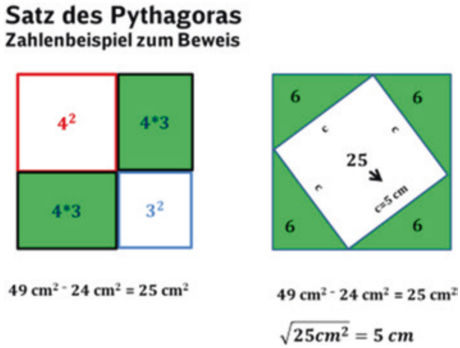

Fig. 3.2 Proof of the Pythagorean theorem

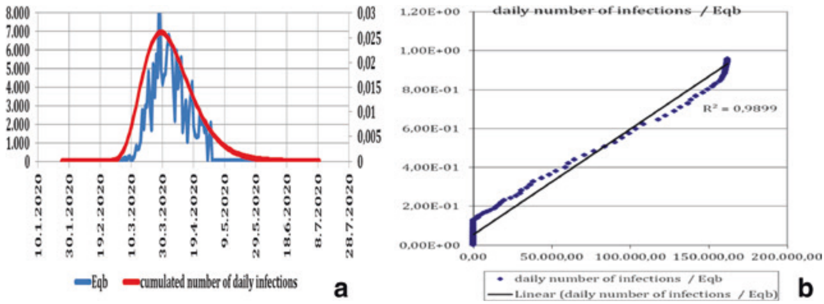

Fig. 3.3 **a** frequency values—probability values, **b** least squares method

account. An example for the development of a mathematical truth is the proof of the Pythagorean theorem (Fig. 3.2). The most widely published is this graphic representation of a numerical proof in which the truth is established by a compelling logic case.

On the other hand, there is the statistical-probabilistic finding of truth, the approximation of an agreement of relationships through a regression test, which is brought about by the method of least squares. This method is used in the further course of comparing the frequency values of infection values and the probability values (Fig. 3.3a, b) from the equibalance distribution. The percentage of the determined coefficient of determination is therefore to be regarded as an approximate value for agreement.

3.3 Replacement of the Infection Rate I(T) Of the Sir Model by the Eqb Function

The infection rate of group I(t) of the SIR model described in SIR model—Wikipedia may be replaced by the parameter values from a frequency distribution, which originate from a temporal survey, a sample. These are the parameters maximum, scatter, skewness and kurtosis, (Fig. 3.4).

From this the functions develop:

$$I(t) = Eqb(t = x; \sigma, max, r, \kappa) * N(total)$$

$$S(t) = N - Eqb(t = x; \sigma, max, r, \kappa)$$

A function for R(t) develops separately from the parameter values from the frequency of the recovered numbers:

$$R(t) = Eqb(t = x; \sigma, max, r, \kappa) * N(recovered)$$

3.4 Preliminary Clarification

Entsprechend daraus werden die Funktionswerte für S und R ermittelt, die dann in dem Zusammenhang zwischen SIR und Eqb Dichte folgende Übersicht bilden, Abb. 3.5a, b, c.

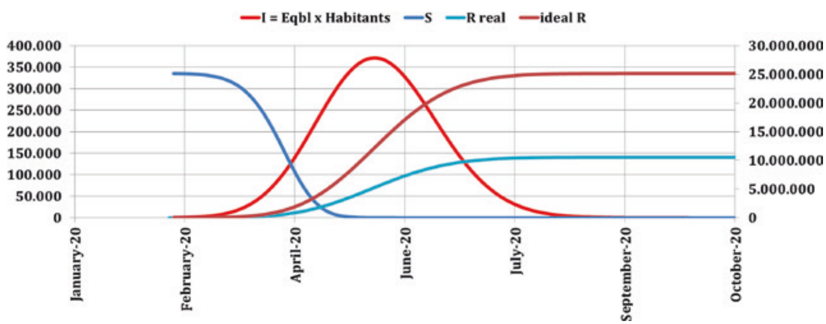

Fig. 3.4 PSIR Probabilistic SIR—Model

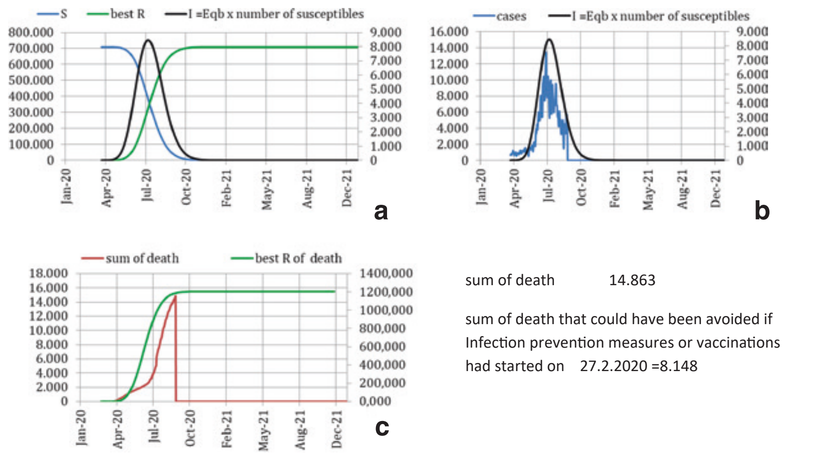

Fig. 3.5 **a** Compilation of the courses S, best R and I x Eqb, **b** cases, I x Eqb, c total of deaths, best R course of avoiding deaths

3.5 Use of Databases

The collection of data takes place via central institutions, which then make entries in a register if a person-related infection has been proven. The corresponding data set is called "Case Numbers", which is set for an agreed district with a defined population. In the Federal Republic of Germany, these are the federal states and their subdivision into administrative districts. Every data record recorded daily is forwarded to a central office, which, in accordance with a set of rules, recommends measures intended to contain the "infection" process.

These databases are publicly accessible and are used in the following explanations. The amount of data collected is large enough to be able to use statistical methods—random testing—to make statements about how the "system" virus will behave in its spread to a population.

4 Introduction: Consideration of an Infection Interval for a Federal State

As an introduction to the following chapters, it is shown how a first “wave” of a pandemic process can be represented in frequency distribution, density curve, incidence forecast, case number forecast, exponent (Fig. 4.1).

The parameter values that are necessary for a density function can be determined from the measured values, which result from the statistics of the interval-based surveys.

The interval consideration begins with the definition of a reference graphic, which results from the frequency distribution of an initially considered initial interval. The four parameters maximum, spread, skewness and kurtosis are transferred to the density function. About its course, it refers to the expected numerical development of the process—in this case the COVID—19 infection process starting in March 2020.

Exponential increase

By determining a 7-day logarithm, conclusions can be drawn about the exponent of the development, which in turn influences all other process-dependent factors in the future. This includes the incidence as well as the increase or decrease in the number of cases.

Regression, coefficient of determination

If the process is observed over time in further subsequent intervals, it soon becomes apparent that fluctuations in the test data occur due to the changing numerical ratio in the frequencies determined, which may be influenced by the day of the week on which the data situation was announced it must be checked

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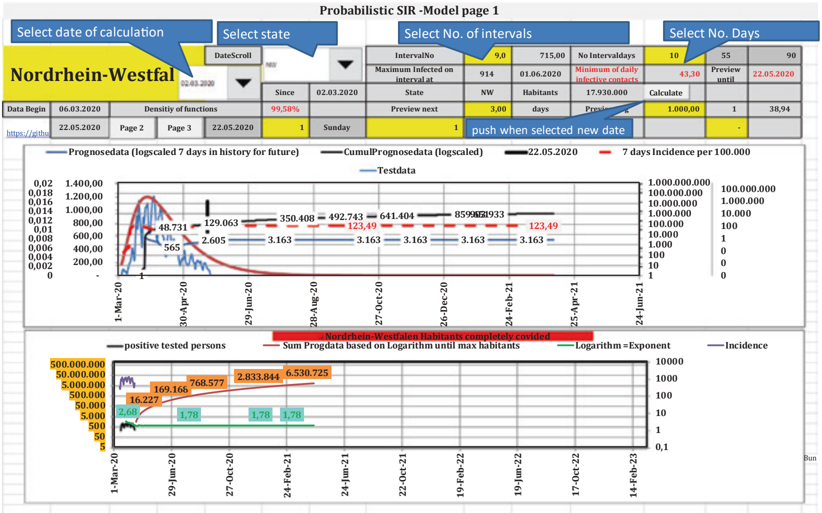

Abb. 4.1 Pandemieprozess (Häufigkeitsverteilung, Dichteverlauf, Inzidenzprognose, Fallzahlenprognose, Exponent)

what is the best relationship between the frequency distribution and the probability density. A use of the regression analysis according to Gaussian design therefore provides information about the agreement if the choice of the days of the week leads to the coefficient of determination being close to 1.

Skewness and Slope (kurtosis) Measure

However, it also shows that it makes sense to consider the rate of increase from interval to subsequent interval, because there may be a short-term increase in the number of cases. Obviously, this cannot be predicted via the frequency distribution, but it is possible by following the slope and the skewness of the density of the initial interval over subsequent intervals. It turns out that the start time of the initial interval has to be adjusted if the positions of the skewness and slope behave as shown between subsequent interval 5 and subsequent interval 6.

Location parameters

It is obviously clear that all position parameters, i.e. maximum, scatter, skewness and kurtosis must be included in the observation, because their values ultimately determine the decision as to how the further course of a process will be.

4.1 Reaching Saturation/Infestation

If it can be deduced from the previous graphic that the pandemic process is declining, then by observing the exponent it can be deduced when the increase in frequency is so steep that an infection saturation of the number of inhabitants of the respective region can be expected as a result (Fig. 4.2). This means that the number of cases determined is identical to the size of the population of the region in which it was recorded.

The accompanying exponent can be calculated from a sampled interval from the corresponding mean logarithm.

It expresses the future course of the process under the condition that the current rate of increase does not change. A prognosis for a future course can only be derived depending on the previous interval. If the course of infection is favorable due to avoidance processes, i.e. the number of cases is reduced more frequently in proportion to a previous interval, the changed skewness testifies to the development.

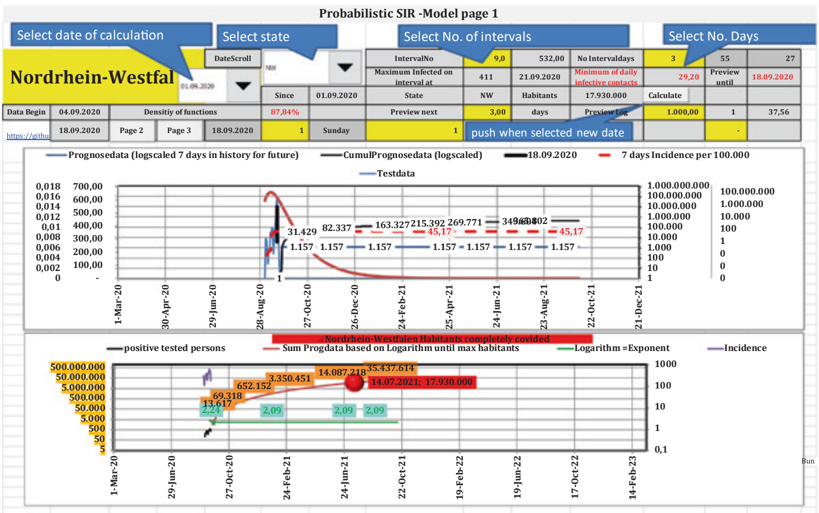

Fig. 4.2 Pandemic process (observation of the exponent, infection saturation)

4.2 Transition to Precautionary Consideration

Decision-makers would like to counteract an infection process early and preventively—and that before an infection process can ever have pathological effects. To do this, it is necessary to have provided the resources ahead of time—i.e. before a process has a start. A preventive consideration using a probabilistic SIR model may shed light on how preventive measures or healing measures are designed in terms of time.

This asks the following questions:

β can be further broken down as: $\beta = q \times \kappa$ the contact rate κ and the probability q of transmission of infection by contact. Coupled with the density Eqb, the infection rate is then equal to the probability of Eqb for each location of the daily reading of infection relative to the number of residents selected in a municipality/region/state.

How many cases of illness or death could have been avoided if

- premature preventive or curative measures
- temporary preventive measures or healing measures could be hit?

The preventive measures or curative measures are listed according to:
Coronavirus—infektionsschutz.de

Keep your distance, observe hygiene, wear a mask in everyday life, ventilate regularly and use the Corona warning app: The AHA+L+A formula is part of our everyday life in times of Corona. We will inform you about what needs to be considered.

Testing for an acute infection with the corona virus SARS-CoV-2 helps to identify infected people and break transmission chains. PCR tests, rapid antigen tests and antigen self-tests are available as tests.

Vaccination against the corona virus SARS-CoV-2 is the most effective protection against COVID-19 and the spread of the virus.

The following graphics show how many deaths could have been avoided if the preceding preventive or healing measures could have worked if they were applied.

For this purpose, the probabilistic SIR model was equipped with a back calculation, which corresponds to the determination of the values of the cumulative curve

- from a period before an initial interval
- from an intensity of preventive measures or curative measures allows modeling that can help to better plan the necessary resources with regard to
- staff
- Time
- Costs
- quality

The following chapter lists cases that may give an insight into probabilistic SIR modeling.

5 The “Infection Curve” I(t) is Replaced by the Skewed, Steep Eqb Density Function

The development of the normal distribution was developed during the lifetime of the author Gauss. A further differentiation with regard to the skewness would have extended the calculation and checking effort for plausibility (checking that the sum of the density distribution converges to 1) many times over. Therefore, different authors have dealt with the problems of the skewed distributions (Fig. 5.1) at different times.

5.1 Right-Skewed and Left-Skewed Hypothetical Distributions

Of course, it is also a matter of detecting those events that are observed beyond the limit values.But where are the limit values to be set if the distributions are not symmetrical, or even worse, the imbalances from sample to sample migrate from the left around the mean to the right? Most processes are subject to influences that prevent a constant scattering of events from being observed. In this respect, the normal distribution must not be used at all. Ways of looking at things like those developed by mathematicians who saw a concrete reason to supplement or replace the normal distribution can help.The decisive factor for replacing the normal distribution with another probability density function is the appearance of so-called “heavy tails”, a “heavy tail” distribution (Fig. 5.2), as is revealed when a series of events tend to deliver measured values that exceed the permissible number of the target exceed.

An additional parameter ρ

$$r := (1 - (\rho\%(x - \mu))) \qquad \text{(Formula 5.1 Credit author)}$$

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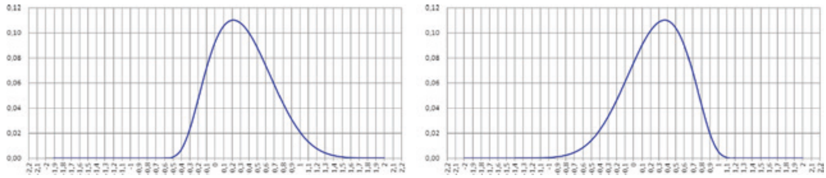

Fig. 5.1 Skewed distributions. (Credit author)

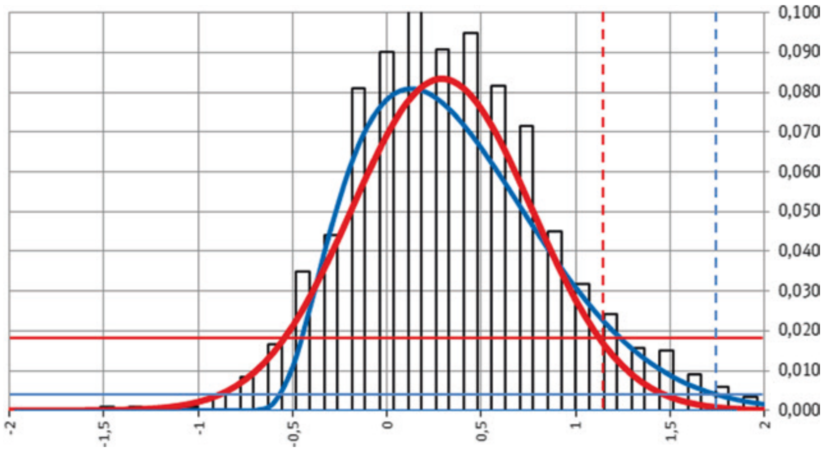

Fig. 5.2 Normal distribution, skewed distributions, heavy tail distributions. (Credit author)

opens up the new probability function to science

$$\mathrm{Eqb}(\mathrm{x};\mathrm{m},\mathrm{s},\mathrm{r}) = \frac{1}{\sqrt{2\pi \mathrm{s}^2}(1-\mathrm{r}(x-m))}\mathrm{e}^{-\frac{\frac{(x-m)^2}{2s^2}}{1-r(x-m)}}$$

(Formula 5.2 Credit author)

respectively.

$$\frac{1}{\sqrt{2\pi\sigma^2(1-\rho(x-\mu))}}\exp-\frac{(x-\mu)^2}{2\sigma^2(1-\rho(x-\mu))}$$

(Formula: 5.3 proof by Andrej Depperschmidt)

Random Ranges of NV and Eqb

6

The differences between the probability density distributions NV and Eqb and their random spreads are significant. This results from the application of the third parameter r or ρ The value range of the standard normal distribution (Fig. 6.1) is in relation to an expected value μ in open intervals in the negative as well as in the positive area. The integral over it is 1. The respective density bins are defined by σ. $\sigma$is derived from the 2nd derivation (intersection with the x -axis) of the NV function. The range between $\pm 3\sigma$results in a probability density of 99.73%.

The graphic shows a symmetrical image with the intersections of the turning points and the 2nd derivative of the function (see Fig. 6.2).

A differentiated picture shows the probability density distribution of the Eqb. The 2nd derivation of the function (Fig. 6.3) determines the intersection points with the x-axis and thus the different σ-positions with regard to an expected value.

This means that those of the Eqb are also different from those of the NV (Fig. 6.4). They are obviously closely related to the described inclination of the scattering r or ρwith effects on the "tails", the ends of the random scattering ranges.

The new Eqb function expands the view to include the skewness of the distributions with the following consequences for the random skew ranges and thus the exceeding of the previously valid limit values.

This case is shown in a table using an example, since the cumulative density of the NV and the multivariate Eqb can vary depending on the different values for the parameters.μ (Fig. 6.4).

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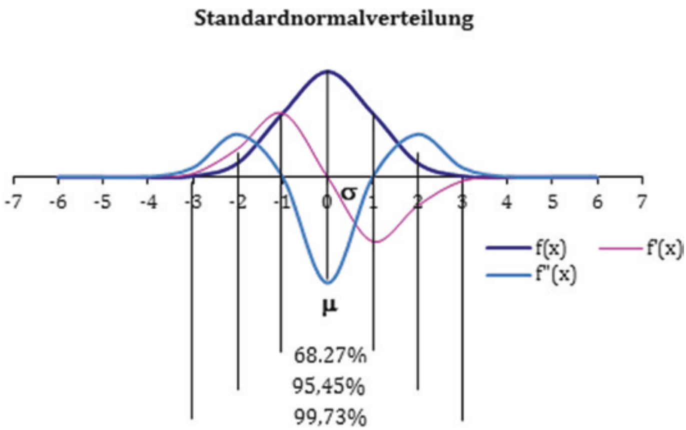


Fig. 6.1 Normal distribution blue, 1st derivative purple, 2nd derivative light blue. (Credit author)

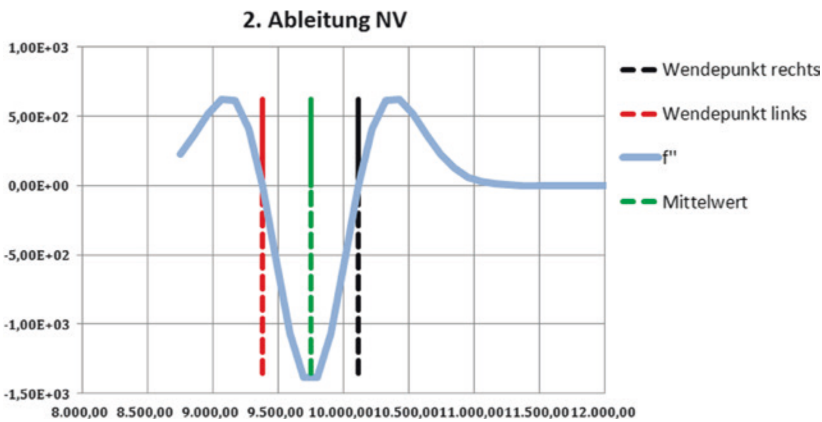


Fig. 6.2 Derivation of normal distribution blue, mean value of normal distribution green, position σ left red, position σ right black. (Credit author)

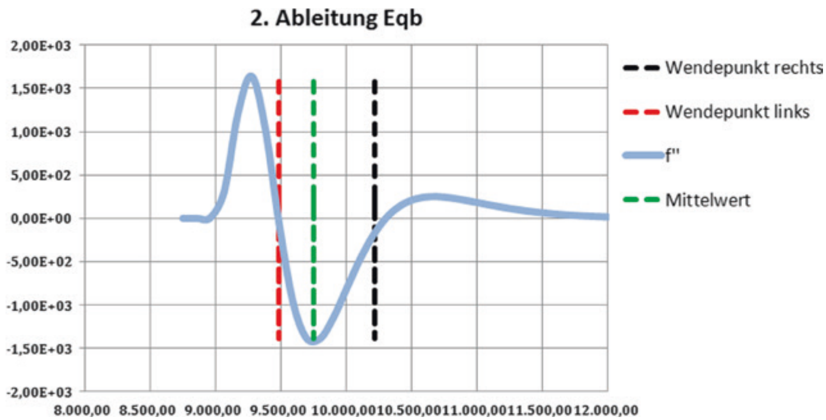


Fig. 6.3 2nd derivation Eqb blue, mean value normal distribution green, position σ left red, position σ right black. (Credit author)

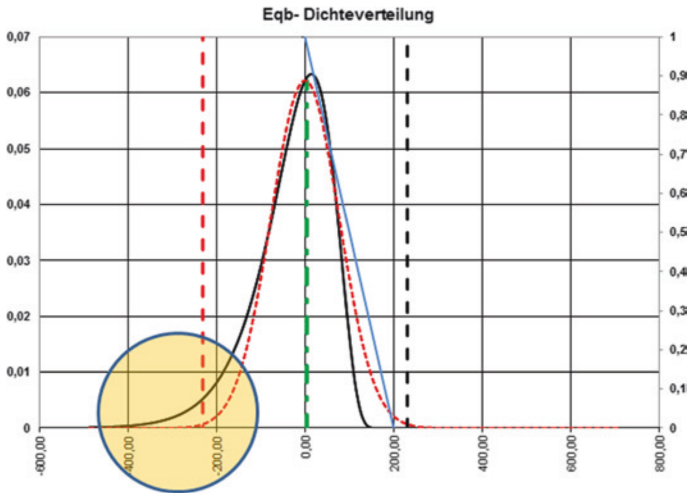


Fig. 6.4 2nd mean normal distribution green, position 3 σ left red, position 3 σ right black, slope ρ light blue, different "tail" circle. (Credit author)

7 Presentation of the Equibalance Distribution, Eqb

Its probability density (Fig. 7.1) remains at 1 in “skewed positions” and includes the normal distribution in the symmetrical case.

However, it also opens up extreme imbalances with a remaining probability density of 1, (Fig. 7.2).

7.1 Concept of Density

Symmetrical manifestations, as they are evident in almost all specialist areas, influence the objective assessment of facts in such a way that they are often used as a basis for judgment. The process world also likes to use simple, memorable graphic representations. The symmetric normal distribution density developed by Gauss is a good example of this. On the other hand, there are numerous asymmetrical process layers for which specially adapted density functions were then developed.

The newly developed equibalance distribution Eqb is intended to remedy the situation by replacing as many of the specially adapted density functions as possible via a skewness parameter.

The newly developed formula for a right- or left-skewed distribution, the “Equibalancedistribution Eqb” for the analysis of measured values, is trend-setting for the quality-effective monitoring and action management. The symmetrical normal distribution previously used for the description is still contained in the Eqb as a simplified special case.

However, due to the mutual influence of the parameters on the values supplied by the Eqb, it will not be possible to estimate individual parameters using normal statistics because they all already occur in the expected value.

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1_7

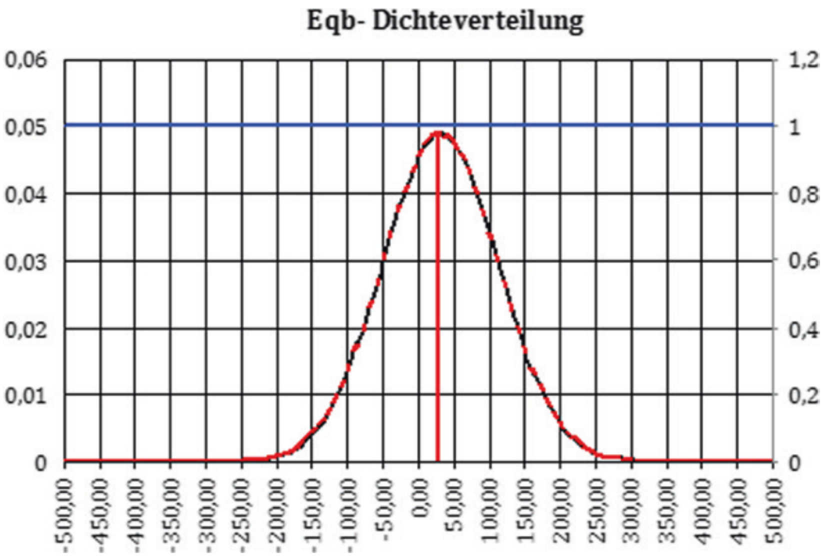


Fig. 7.1 Eqb density distribution. (Credit author)

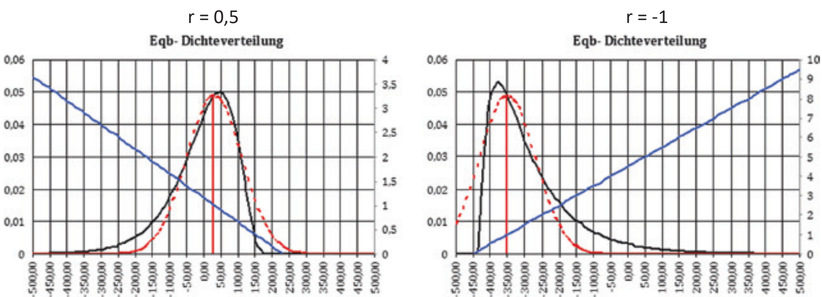


Fig. 7.2 Eqb density distributions, normal distribution. (Credit author)

The mathematical function Equibalancedistribution Eqb is examined:

$$\frac{1}{\sqrt{2\pi\sigma^2(1-\rho(x-\mu))}} \exp - \frac{(x-\mu)^2}{2\sigma^2(1-\rho(x-\mu))} \qquad \text{(Formula 7.1)}$$

7.2 Addition of the Parameter Kurtosis to the Density Eqb

It became obvious that statistical surveys and the resulting frequency distributions are often not symmetrical with regard to the distribution around an expected value or mean value. Rather, the values incline around a maximum, resulting in skewness and kurtosis.

The following equation, density, was used in the following evaluations.

$$Eqb(x;\sigma,max,r,\kappa) = (\frac{1}{s*\sqrt{\left(2\pi\left(\frac{1-((r)*(x-max))}{\kappa}\right)\right)}} * EXP\left(\left(-\left(\frac{1}{2}*\frac{\left(\frac{x-max}{\sigma}\right)^2}{1-(r*(x-max))}\right)*\kappa\right)\right)$$

(Formula 7.2)

7.3 The Basis for the Eqb Density, the Test Series Results

7.3.1 Density Eqb in Replacement of I(T), Parameters, Data Sources

The data of the measurement series originate for:

- Tests: https://github.com/nytimes/covid-19-data/blob/master/us-states.csv
- Vaccinations: https://raw.githubusercontent.com/owid/covid-19-data/master/public/data/vaccinations/us_state_vaccinations.csv

7.3.2 Functions and Parameter Values

It represents the functions:

- N is the total number of residents
- S (susceptible): the population size of those available from the total number of residents

- I (infected: "infected"); the population size of the infected according to the test set from S
- R (Recovered): the population size of the recovered according to test set from a test set R

In this case, I(t) is replaced by the density function Eqb, which results from the result in parameter values of the frequency distribution of the measured values of a population, which are:

- Maximum value of the series of measurements/sample
- and estimation of the skewness:

$$\widehat{\sigma}^2 = s_n^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - max) \qquad \text{(Formula 7.3)}$$

- -and the estimated skewness of the sample values according to:

$$\widehat{\nu} = \frac{1}{n}\sum_{i=0}^{n}((x_i - max)/s)^3 \qquad \text{(Formula 7.4)}$$

as well as the estimated kurtosis of the sample values

$$\widehat{\kappa} = \left(\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum_{i=0}^{n}((x_i - max)/s)^4\right) - \frac{3(n-1)^2}{(n-2)(n-3)} \qquad \text{(Formula 7.5)}$$

The density therefore develops from the aforementioned parameter values in the form:

$$\sigma = sqrt(\widehat{\sigma}^2)$$

$$md = max(h)$$

$$r = \widehat{\nu}$$

$$\kappa = \widehat{\kappa}$$

which can be found in the Eqb (Equibalancedistribution) as listed.

$$Eqb(x;\sigma,max,r,\kappa) = (\frac{1}{s*\sqrt{\left(2\pi\left(\frac{1-((r)*(x-max))}{\kappa}\right)\right)}} * EXP$$
$$\left(\left(-\left(\frac{1}{2}*\frac{\left(\frac{x-max}{\sigma}\right)^2}{1-(r*(x-max))}\right)*\kappa\right)\right)$$

8 Incidence from a Probabilistic Point of View

8.1 Infection Management in Connection with the Course of the Incidence

Infection management as such can be viewed as a system that—apart from the infection system—COVID—can map some other systems. Infections are part of a pathological process that is generally regarded as "harmful". The term "infection" translates the "act inward" as an act of surrender. In connection with the present work, this is the transmission of pathogens. In a general context, it is a basic formulation that applies to many contexts.

In this respect, infection management is the "handling of handovers" and that under

- more temporal
- more costly
- more qualitative
- personal
- more material

respect.

There are differences between the types of processes, e.g. infectious disease of living beings, computer virus infestation, deliberate dissemination of false reports of damage, neglect of educational systems…, i.e. a number of processes for which the probabilistic SIR model can provide information if the statistical basis given for it.

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1_8

This applies to processes whose starting conditions and subsequent sequence are essentially based on experience that can serve as a basis for a comparison.

This was not possible with the COVID infection, since no comparable process from the past can serve as a basis, which is meant from the fundamental difference that the COVID process events revealed different qualities that only appeared over time the occurrence of variants that cannot be qualified as long as their behavior over time and measurements is not known.

All based on this in the course of the experience of infection management, the "handling of handovers", be it health-damaging viruses or data-destroying viruses or personality-damaging FakeNews or inadequate support and equipment of educational institutions.

In all cases, the processes can be divided into phases, which can be outlined as follows, in the specific case of infectious disease of living beings.

8.2 Phase structure

The phases are based on the probabilistic SIR model.

Phase S

Phase S depending on Phase I = Eqb x Habitants based on the frequency distribution of the test series.

*Quote: (*http://www.medizinfo.de/fections/allgemeines/phases.shtml*)*

Beginning of the infection process An infectious disease proceeds in several phases from the beginning of the infection.

Invasion phase: This phase describes the actual contagion. The pathogen enters the body. However, it initially remains inactive and does not multiply.

Incubation phase: Depending on the pathogen, multiplication occurs after hours or days, in which the pathogen has become accustomed to its new environment. However, there are still no complaints. In many infectious diseases, at the end of this phase, there is a massive, often almost explosive, multiplication of the pathogens.

The incubation period refers to the period from infection to the onset of the disease—considered to be the first two phases of an infection. It varies in length depending on the infectious disease, e.g. For example, diphtheria lasts 1 to 7 days, rubella 14 to 21 days, but the incubation period for AIDS can last more than 10 years.

Phase of illness: Now the first symptoms appear. Depending on the severity of the infection, there may be slight symptoms, e.g. B. slight headache or hoarseness *or local redness. But I can also develop serious symptoms such as B. high fever, dizziness and weakness.*

Overcoming phase: After surviving an infectious disease, all pathogens are destroyed in this phase.

Phase I

Phase I develops over the entire duration of the process. It is determined by the series of tests, which provide information about their results = frequency distribution and probability density about a predicted future of the process depending on the phases S and R.

Phase R

Experience shows that a recovery process (R) only occurs after time intervals

- the identification of the cause, the pathogen
  - based on empirical values
  - based on research results
- the development of prevention and treatment measures
  - behaviors
  - protection
  - Medication
- a test phase of preventive or treatment measures.
  - Medication by means of random tests on volunteers
  - Protection via personal protective equipment
  - Behaviors about restrictions on contact
- the production of preventive or treatment measures
  - Accompanying the determination of suitability from the results of the test phase
    Determination of the quantity structures
    Infrastructure (test center, information center, hospitals)
    Personnel requirements (ambulance transport, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists)
    Material needs (medication, protective equipment)
- the provision of the elements of the quantity structures also according to the checklists:

Quote: Baden-Württemberg State Health Office in the Stuttgart Regional Council; Manual for corporate pandemic planning, second expanded and updated edition, December 2010.

Pre-pandemic measures

- V1 Operational and personnel planning
- V2 Procurement of medical and hygiene means
- V3 Information and Communication
- V4 Preliminary medical planning

Measures during the pandemic

- P1 Maintenance of minimum operation
- P2 Organizational measures for staff
- P3 External information
- P4 Medical measures
- P5 Measures for relatives and foreign employees

Measures after the pandemic

- N1 return to normal

the observation of the effect and feedback of the results from the phases on process corrections in the course

At the beginning of the "COVID process, 1st wave" it was not possible to plan the phases because none.

There was experience with the phases mentioned, but success with regard to the positive development has set in as soon as.

- behaviors
- protection
- Medication

were used.

The ideal, but unrealizable recovery process (R) begins directly with the onset of the disease process, (Fig. 8.1).

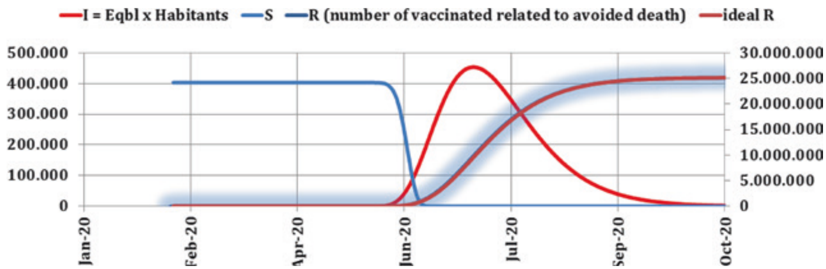


Fig. 8.1 Probabilistic SIR model but unrealizable recovery process (R) for the COVID process. (Credit author)

Infection, Avoidance and Healing Process, Feedback

9

9.1 Infection Process

According to MedizInfo®: Phases of an infectious disease, the phases of infections are as follows:

Invasion phase: This phase describes the actual contagion. The pathogen enters the body. However, it initially remains inactive and does not multiply.

Incubation phase: Depending on the pathogen, multiplication occurs after hours or days, in which the pathogen has become accustomed to its new environment. However, there are still no complaints. In many infectious diseases, at the end of this phase, there is a massive, often almost explosive, multiplication of the pathogens. The incubation period refers to the period from infection to the onset of the disease—considered to be the first two phases of an infection. It varies in length depending on the infectious disease, e.g. For example, diphtheria lasts 1 to 7 days, rubella 14 to 21 days, but the incubation period for AIDS can last more than 10 years.

Phase of illness: Now the first symptoms appear. Depending on the severity of the infection, there may be slight symptoms, e.g. B. slight headache or hoarseness or local redness. But I can also develop serious symptoms such as B. high fever, dizziness and weakness.

Overcoming phase: After surviving an infectious disease, all pathogens are destroyed in this phase.

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1_9

9.2 Avoidance and Healing Process, Feedback

From the course of all observations inherent to the “system virus” it was taken that as soon as knowledge about the behavior increased, processes of avoidance and healing took shape, which were then reflected in regulations, ordinances and laws. Regular feedback is necessary to determine how successfully/unsuccessfully created systems and implemented processes are.

It turned out that as soon as the “system virus” was successfully detected, it could be used to develop counter-systems.

These include the well-known and successful systems for:

1. Avoidance, Whose Processes (Actions and Effects) Are
   Get vaccinated, limit contacts, keep your distance, wear a mask, wash your hands regularly, do not put your hands on your face, do not touch shopping trolleys, doorknobs and railings, limit travel.
2. Healing, Whose Process (Actions and Effects) Are
   Early detection of the infection, treatment according to the severity of the infection (quarantine, hospitalization).
3. Feedbacks Whose Process (Actions and Effects) Are
   Timely recognition of the success/failure of 1 and 2, adjustment of systems 1 and 2

The systems presented and their processes may be reflected in concrete actions, the effects of which may then serve to adapt.

The systems and their processes are taken from the Baden-Württemberg State Health Office in the Stuttgart Regional Council; “Manual for corporate pandemic planning”, second expanded and updated edition, December 2010

Representation of a Process Management

10

There may be enough reasons from a human point of view—as they may be listed in Chap. 1 Reason, derived from a letter to the editor. Ultimately, however, the participants and their behavior decide how an infection can spread and how it can be "put in its place" again. Since all systems are characterized by their essential influencing factors:

- quality
- Costs
- Events

This includes the following phases in process management—infection events, listed below from: Baden-Württemberg State Health Office in the Stuttgart Regional Council; "Manual for corporate pandemic planning", second expanded and updated edition, December 2010.

10.1 Phase Scheduling

A phase schedule (Fig. 10.1) can be created based on a chronological sequence, which can be used to plan and monitor the process.

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1_10

Activities	Weeks																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Phase S																			
Beginning of the infection process																			
Invasion phase, infection, pathogens do not multiply.																			
Incubation phase: explosive multiplication of the pathogens.																			
Disease phase: first symptoms, complaints																			
Phase I.																			
Provision of infrastructure (test center, information center, hospitals)																			
Carry out test series																			
Preventive planning for personnel requirements (patient transport, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists)																			
Information events for the population																			
Phase R.																			
Identification of the cause, the pathogen																			
Carry out test series																			
Collection of empirical values																			
Collection of research results																			
Continuation of information events for the population																			
Development of prevention and treatment measures																			
Behaviors																			
protection																			
medication																			
Test phase of avoidance and treatment measures																			
Medication by means of sample tests on test subjects																			
Protection through personal protective equipment																			
Behaviors about contact restrictions																			
Production of preventive and treatment measures, procurement of personnel																			
Determination of the quantity structures																			
Infrastructure (test center, information center, hospitals)																			
Personnel requirements (ambulance, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists)																			
Material requirements (medication, protective equipment)																			
Pre-pandemic action																			
V1 Operational and personnel planning																			
V2 Procurement of medical and hygiene products																			
V3 information and communication																			
V4 Preparatory Medical Planning																			
Measures during the pandemic																			
Carry out test series																			
P1 Maintaining minimum operation																			
P2 Organizational measures for the staff																			
P3 External information																			
P4 Medical measures																			
P5 measures for relatives and foreign employees																			
Post-pandemic measures																			
N1 return to normal																			
Observation of the effect and feedback of the results from the phases on process corrections in the course.																			

Fig. 10.1 Phase planning as a template for the first 20 weeks after identification of a pathogen (virus). (Credit author)

10.2 Observed, Recorded Infection Process in Time Intervals

It can be seen that the first few weeks decisively determine how the activities undertaken affect the development of an infection process.

Even if the infection process cannot be fully recognized in a timely manner, activities carried out quickly can result in the number of deaths and post-infection cases being lower than activities carried out with a delay. A probabilistic SIR model from a real development provides information on how a process course of phase R is changed if a subsequent population can be protected by identifying an outbreak in a starting population.

For this purpose, phases of the development are considered, the different—probabilistic characteristics of the parameters. Have mean as maximum, spread, slope and kurtosis—over time according to the collection of case numbers.

If the process status is retained in its temporal/frequent quality, the exponential expression of the development, (Fig. 10.2), is decisive for a preview of when an infection of the population can be expected—the exponent would remain at its current level (habitants completely covided).

10.2.1 1st Infektions-Intervall

(See Fig. 10.2)

10.2.2 2nd Infection Interval

A subsequent interval shows that preventive measures had taken place, as a result of which the parameters had an effect at the expense of the changed infection process. The contamination was avoided because the exponential development was stopped, (Fig. 10.3).

From the history of the development it was observed that all avoidance measures according to the regulations were obviously successful.

However, the findings from the subsequent time intervals showed very clearly that the chemical-biological system of the virus population was designed to develop variants that counteract infection avoidance.

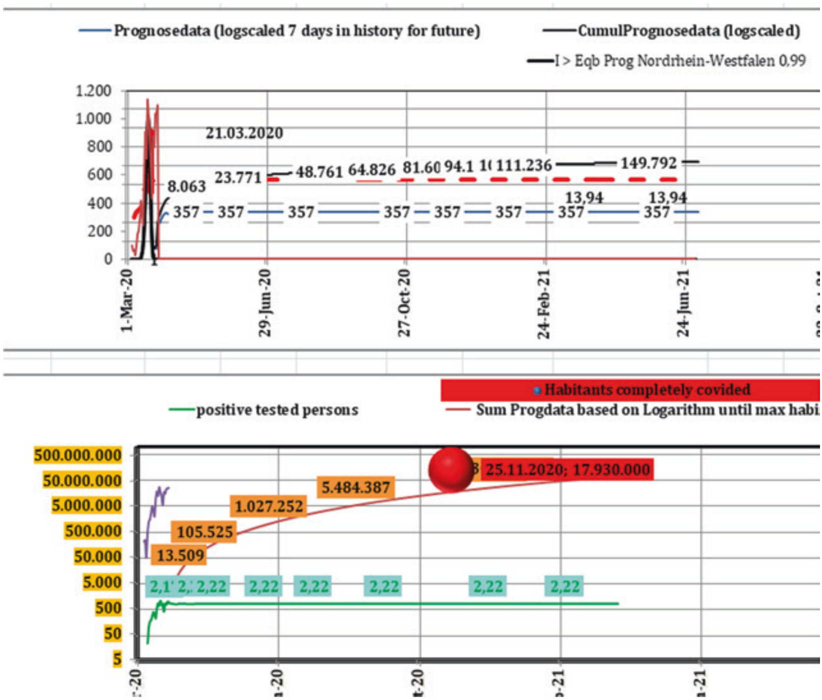


Fig. 10.2 Process status 1. Interval in its temporal/frequent quality, exponential development, epidemic. (Credit author)

10.2.3 3rd Infection Interval

The revelation of the 3rd interval indicates the success of all avoidance measures, because both the displayed frequency distribution and the exponential development show that the “wave” has passed, (Fig. 10.4).

In particular, the reduction in the exponential curve from interval 1 to interval 3 from 2.22 to 1.29 clearly indicates the decrease in the number of cases and their continuation over time in the prognosis.

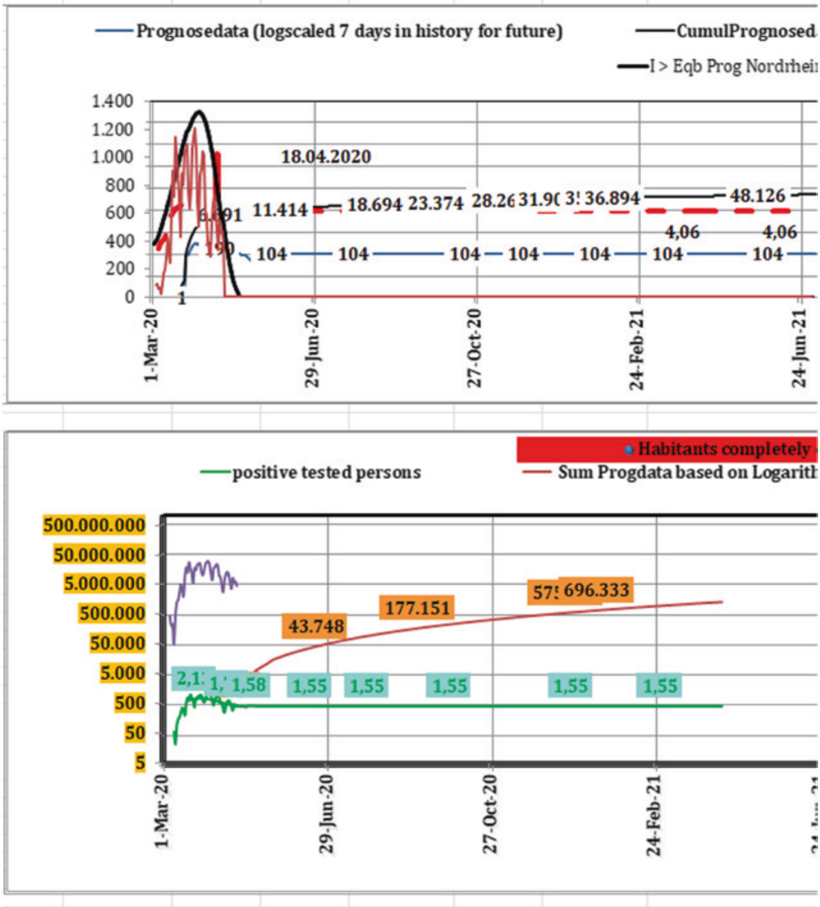


Fig. 10.3 Process status 2. Interval in its temporal/frequent quality, exponential development. (Credit author)

10.2.4 Temporal Correlation of Avoidance Process/ Probabilistic Infection Process

According to all the insights experienced in the COVID process, one essential remains:

"The virus remains a constant companion".

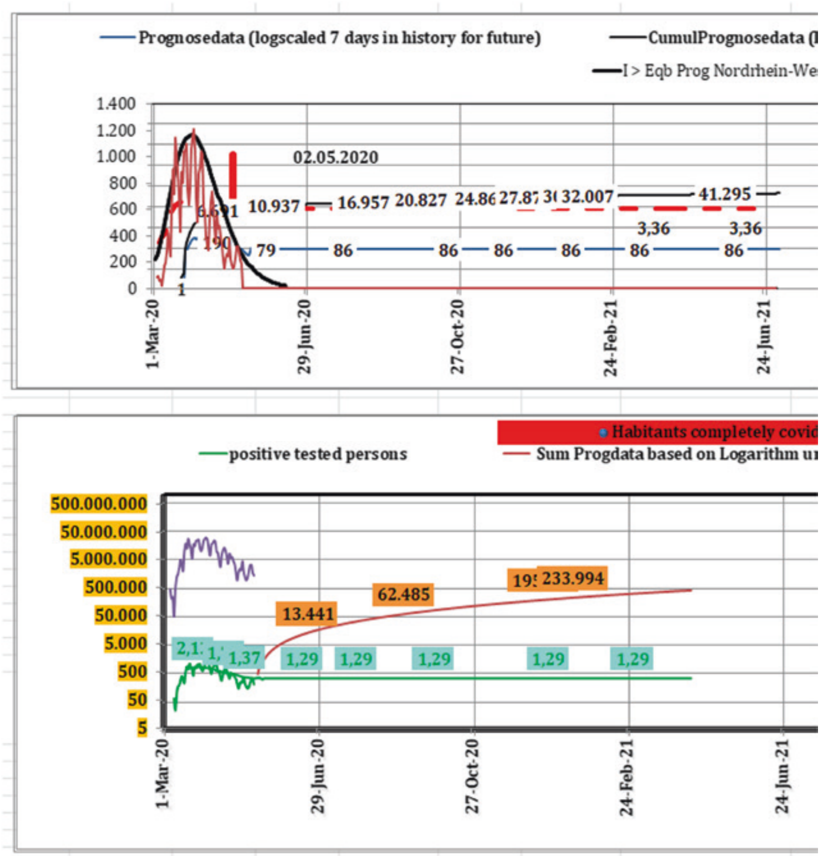


Fig. 10.4 Process status 3. Interval in its temporal/frequent quality, exponential development. (Credit author)

In contrast to regularly occurring infection processes, a COVID infection takes a different course. This is characterized by a dynamic that deviates from conventional, well-known processes in that the originators change their identity.

In this respect, preventive measures should be designed in such a way that the properties of a pathogen are recognized as early as possible and that all activities of a management process can then be tackled.

With the beginning of recognition, all phases, as described in the previous chapters, may be controlled in such a way that they lead to the necessary time, quality and quantity requirements being met, deviations being recognized early and countermeasures being taken.

In addition, it should be listed how avoidance activities in their frequency and their time intervals must precede an infection process in order to be effective. In the avoidance intervals listed below, it becomes apparent that there are overlaps in the correlation between the avoidance process and the consideration of a probabilistic infection process, which means that it depends to a large extent on how early the nature of a pathogen can be recognized and how quickly one can "resistance" can be set in motion. The following interval representations are shown for this purpose.

10.2.5 1st Infection Interval/Avoidance Interval

To understand how the correlation is to be understood, a representation of the corresponding PSIR models may provide information. For this purpose, the models that initially match in terms of time are shown in (Fig. 10.5).

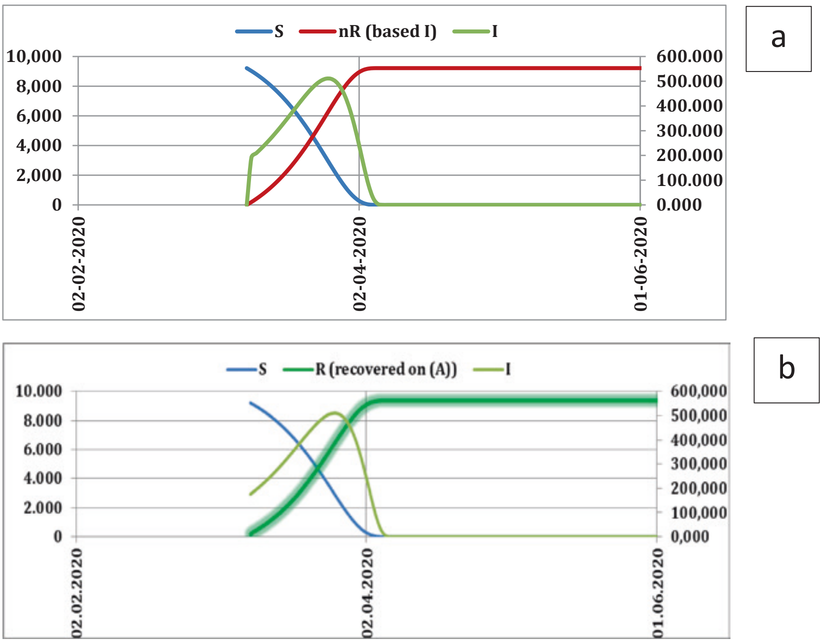


Fig. 10.5 **a** Infection interval, **b** avoidance interval. (Credit author)

In both figures, the expected functions of the probabilistic density and their cumulative trend in the increase in the number of cases, as well as the opposite trend in the decrease in the number of cases are shown.

For figure a is therefore represents the current status

- Decrease in—not yet infected (S) but susceptible
- the increase in the number of infected (nR based on I) as the sum of those who have not recovered
- as well as the density (I)

based on the collected data from case number statistics.

For figure b is therefore represents the current status

- Decrease in—not yet infected (S) but susceptible
- the increase in the number of infected (R based on I) as the sum of those who have recovered
- as well as the density (I)

based on the collected data from case number statistics.

If the temporal courses of both cases are shown superimposed, it can be seen that an avoidance process that coincides with the infection process at the beginning allows a number of unavoidable infections to be predicted in number, (Fig. 10.6).

If the data is presented in its context, (Fig. 10.7), the numerical analysis based on the probabilistic modeling via PSIR results in the statement that at the time of the survey 11,224 cases were disclosed, the proportion of which could be avoided—because initiated at the beginning of the infection process—20.79% or 2,333 cases included.

10.2.6 2nd Infection Interval/Avoidance Interval

In a further consideration, the number of infections that could have been avoided should be shown if the avoidance process—through early identification and the subsequent management process—could have started 14 days earlier.

For this purpose, the infection interval and the avoidance interval are superimposed in Fig. 10.8.

If the temporal courses of both cases are shown superimposed, it can be seen that an avoidance process that coincides with the infection process at the

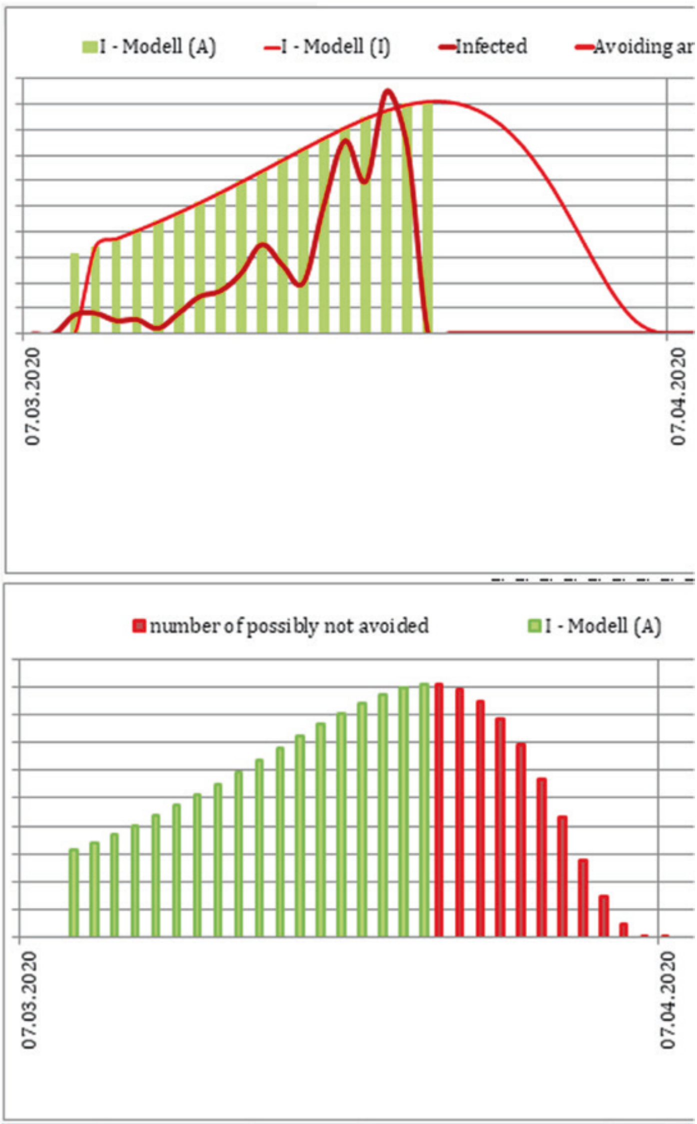


Fig. 10.6 Infection interval, avoidance interval. (Credit author)

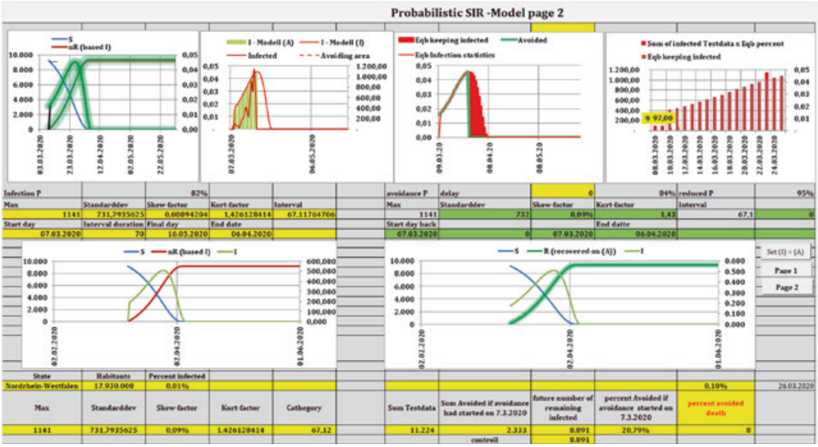


Fig. 10.7 Correlation **a** infection interval, **b** avoidance interval. (Credit author)

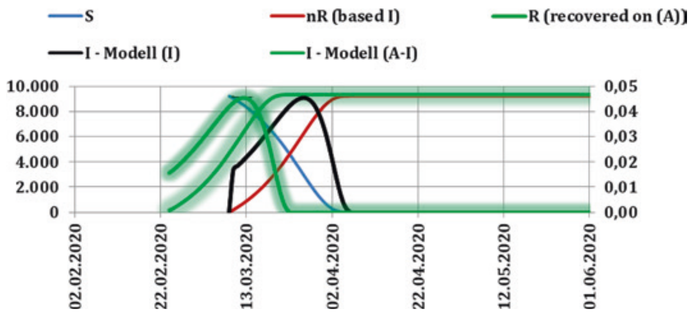


Fig. 10.8 Superimposed infection interval, avoidance interval. (Credit author)

beginning allows a number of unavoidable infections to be predicted in number, (Fig. 10.9).

Attention is drawn to a common interface, which is decisive for the calculation

- the avoidable number of cases
- the unavoidable number of cases

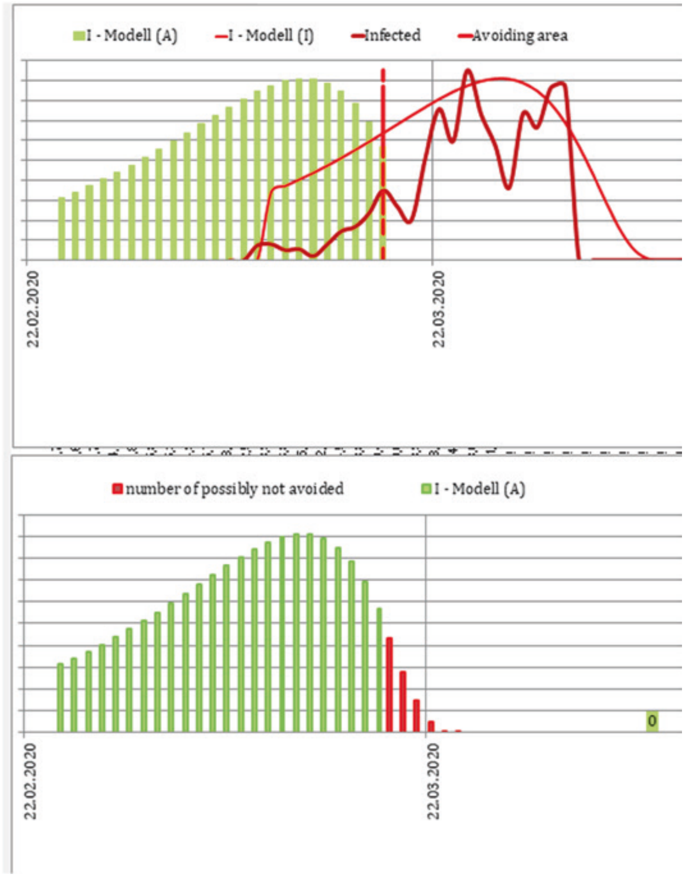


Fig. 10.9 Superimposed on infection interval, b avoidance interval. (Credit author)

see Fig. 10.10.

They are revealed in the following graphic. Obviously, an infection process can be influenced with a foresighted, early detection of the situation and the appropriate management of avoidance. The corresponding figures from the evaluation are also listed, (Fig. 10.11).

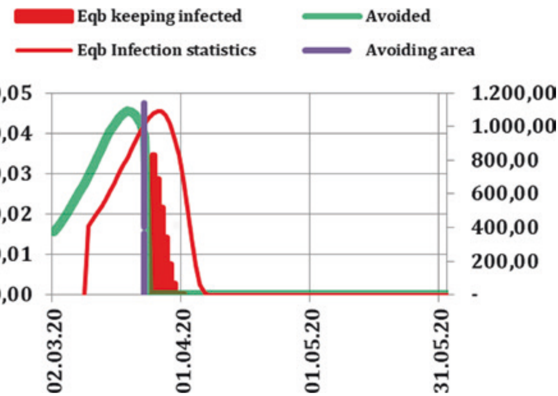


Fig. 10.10 Avoidable case numbers, unavoidable case numbers. (Credit author)

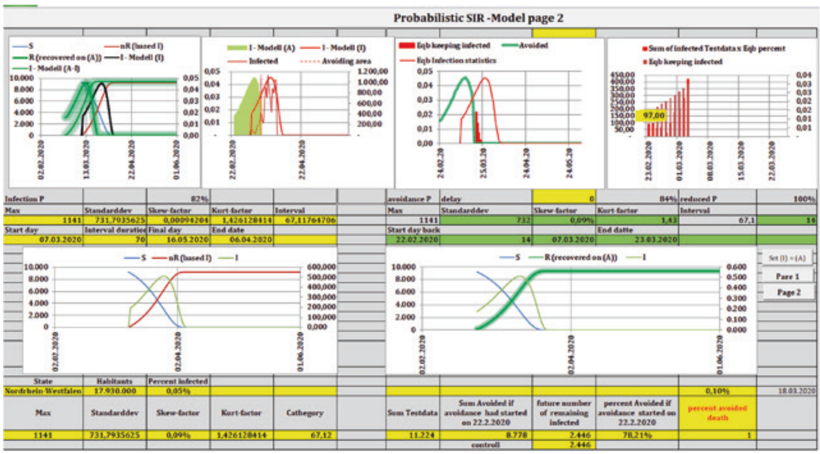


Fig. 10.11 Correlation a infection interval, b avoidance interval. (Credit author)

If the data is presented in its context, (Fig. 10.11), the numerical analysis based on the probabilistic modeling via PSIR results in the statement that at the time of the survey 11,224 cases were disclosed, the proportion of which could be avoided—because initiated at the beginning of the infection process—78.21% or 8,778 cases covered.

10.2.7 Detection of Turning Points

For the completeness of the approach, it should be pointed out that an initially measured process with an increasing number of cases can only be regarded as decreasing if the gradient decreases in a sub-interval. This case can be derived if the corresponding density function indicates a change in slope. It has been proven that the density Eqb is a function, because at least:

$$\lim_{x \to x0} f(x) = f(x0)$$

Then there also exists a 2nd derivative in the form that it suggests that in the case of the existence of two.

0-place the function also has two inflection points and has a maximum. The corollary to this is that a frequency distribution indicates an inflection point when the corresponding density provides an analytical clue, (Fig. 10.12).

If these prerequisites are included for the consideration of the case number development, it can be deduced that an infection process continues to increase if the frequency parameters via the density function do not show that 2 turning points are visible and therefore no maximum is to be expected. This is Fig. 10.13 in the following figures. a, b and 10.14 demonstrated.

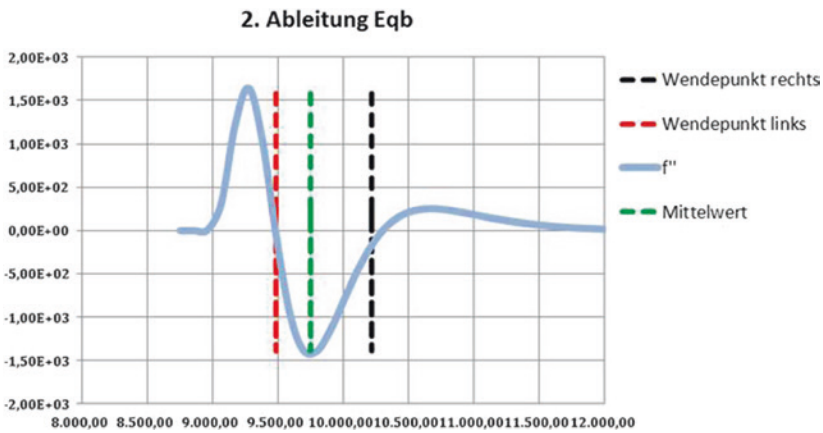


Fig. 10.12 2nd derivative of the density Eqb, turning points, maximum = mean value. (Credit author)

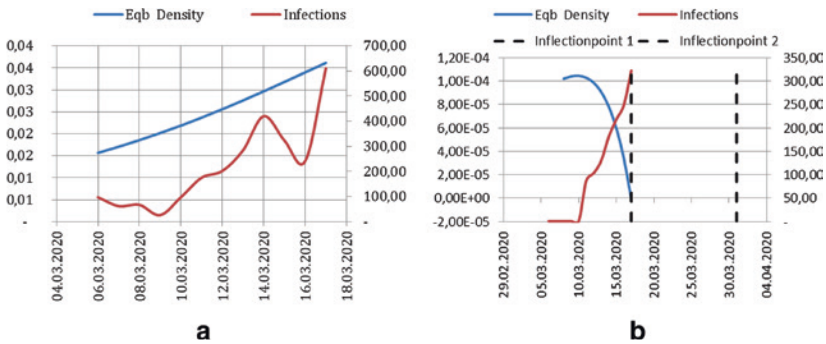


Fig. 10.13 **a** frequency/density, derivative of the density Eqb, **b** an inflection point, no maximum. (Credit author)

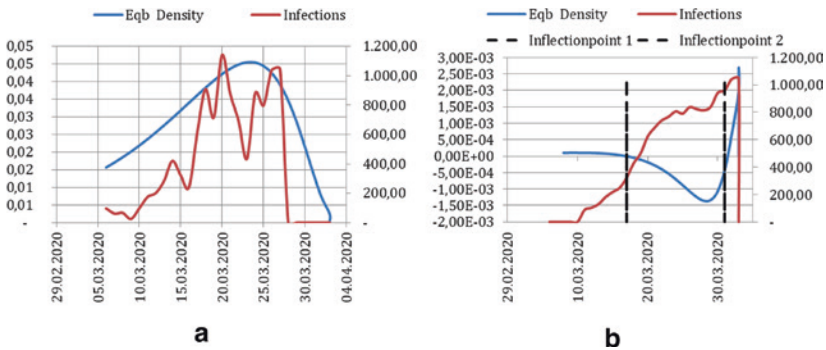


Fig. 10.14 **a** frequency/density, derivation of the density Eqb, **b** two turning points, one maximum. (Credit author)

From the above considerations it can be concluded that:

- as long as there is a density that can be used to deduce parameter values (maximum, scatter, skewness, kurtosis) from statistically collected values, which excludes the existence of at least 2 turning points, the number of cases will continue to increase and, to put it prosaically:

"The end of a wave is not in sight"

The following figures show that there is a maximum, so it can be assumed that it is no longer possible to catch up with the ongoing infection process and to throttle the number of cases.

The confidentiality of the statements in the relationship between density and frequency distribution can be supported by the coefficient of determination that in the regression should not be less than 67%, Figs. 10.15a, b und 10.16a, b.

10.2.8 Infection Interval/Avoidance Interval

All avoidance processes can be recorded and represented statistically in terms of quality and quantity. A change in a numerical increase or decrease in avoidance activities may also have an impact on management behavior. Therefore, it is shown how the influence on the process is, not only with a 14-day lead time, but also by shortening the time interval in which the avoidance process takes place. The corresponding parameter for this is then the scatter from the avoidance activities over the corresponding time interval. Be σ = s; from 722 reduced onto 400.

In a further consideration, the number of infections that could have been avoided is shown if the avoidance process—through early identification and the subsequent management process—could have started 14 days earlier with a scatter of s = 400. For this purpose, the infection interval and the avoidance interval are superimposed in Fig. 10.17.

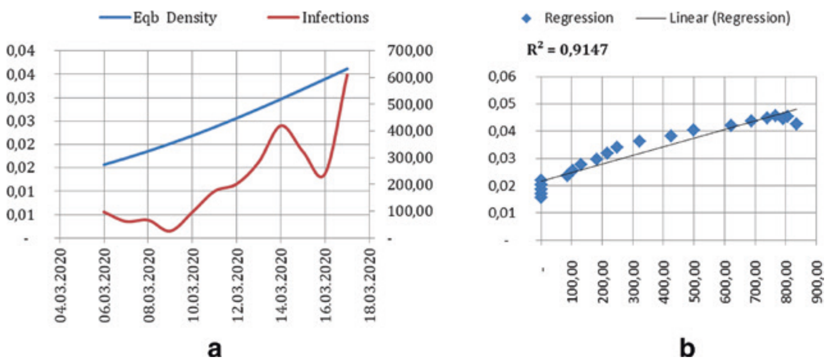


Fig. 10.15 a frequency/density, derivation of the density Eqb, b two turning points, one maximum. (Credit author)

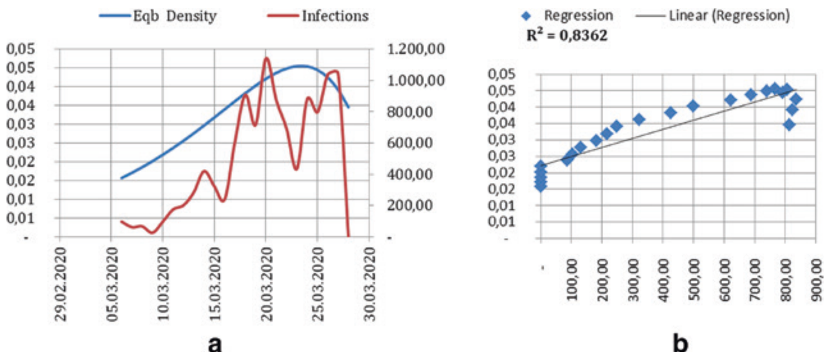


Fig. 10.16 **a** frequency/density, derivative of the density Eqb, **b** two turning points, one maximum. (Credit author)

If the temporal courses of both cases are superimposed, it can be seen that an avoidance process that coincides with the beginning of the infection process allows a number of unavoidable infections to be predicted in number, (Fig. 10.18).

If the data is presented in its context, (Fig. 10.19), the numerical analysis based on the probabilistic modeling via PSIR results in the statement that at the

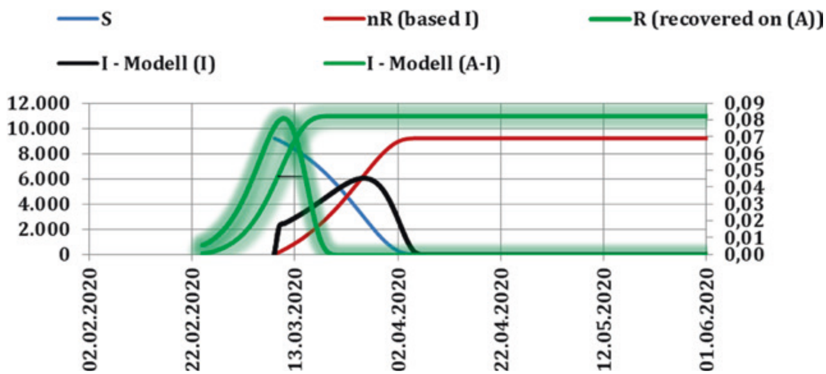


Fig. 10.17 Superimposed infection interval, avoidance interval

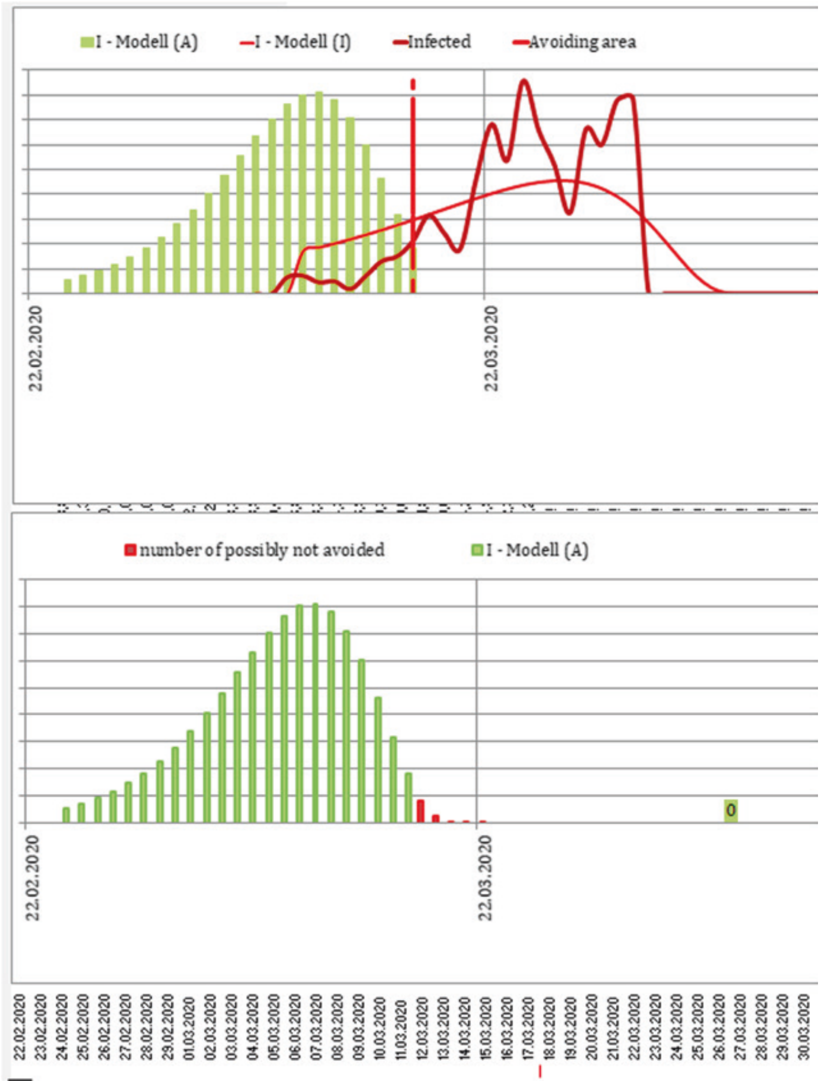


Fig. 10.18 Superimposed on infection interval, b avoidance interval. (Credit author)

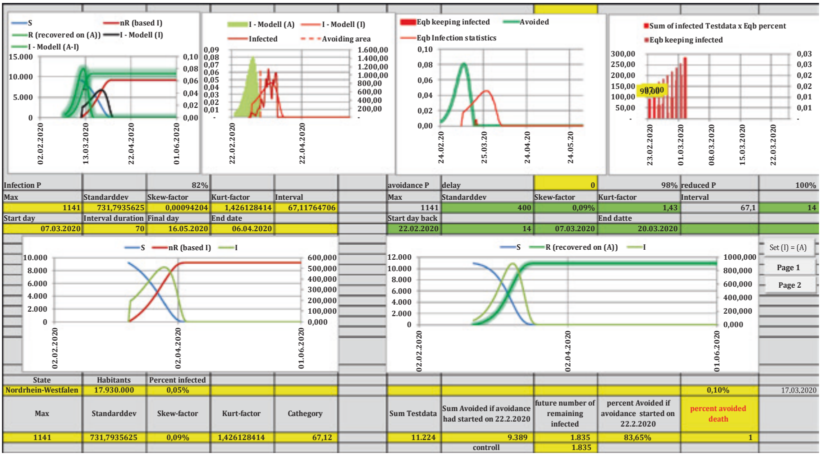


Fig. 10.19 Correlation **a** infection interval, **b** avoidance interval. (Credit author)

time of the survey 11,224 cases were disclosed, the proportion of which could be avoided—because initiated at the beginning of the infection process—81.65% or 9,989 cases covered.

10.3 Phase Planning within a Statistical/Probabilistic View

The demand that emerged from the previous ideas boils down to the fact that all efforts to get an infection process “under control” are measured by how successful they are. Therefore, the phases listed above may be timed within the preceding period in a planned manner. An example in Fig. 10.20 shows the superimposition of the run-up numbers for an avoidance process before the start of an infection process for a vaccination process whose vaccination rate is based on the probabilistic forecast.

For preventive management of pandemic avoidance, all facilities that qualify for such management must be made available.

One recommendation is that—when it comes to biological processes—project management should be set up in close connection with Total Quality Management (TQM).

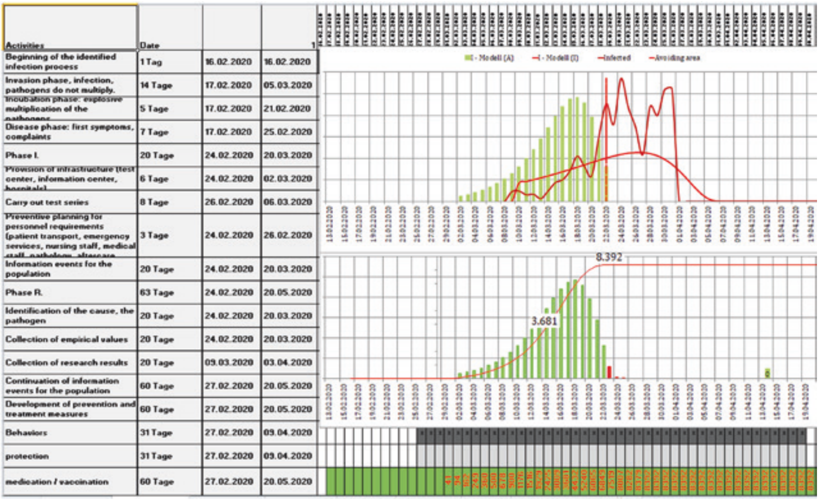


Fig. 10.20 Phase planning within a statistical/probabilistic view. (Credit author)

This ensures that all important units that are necessary for the control, the management of resources, times and qualities are connected in a central location—be it digital or physically networked—and can be displayed clearly and coherently.

10.4 Phase Planning Supported by Network Planning Technology

A precautionary management of the pandemic planning can be supported by a network planning technique, (Fig. 10.21).

It links management activities by determining the order in which they are interdependent when projected onto time intervals.

It thus supports the planning of resources (hardware, costs, duration of use) over time intervals and makes it possible to check performance. This makes it possible to monitor performance levels in such a way that if they deviate, the consequences for the schedule become obvious.

The data generated from the network plan can be displayed in a time chart, a so-called bar chart, whose individual activities are shown according to their chronological length according to their existing links.

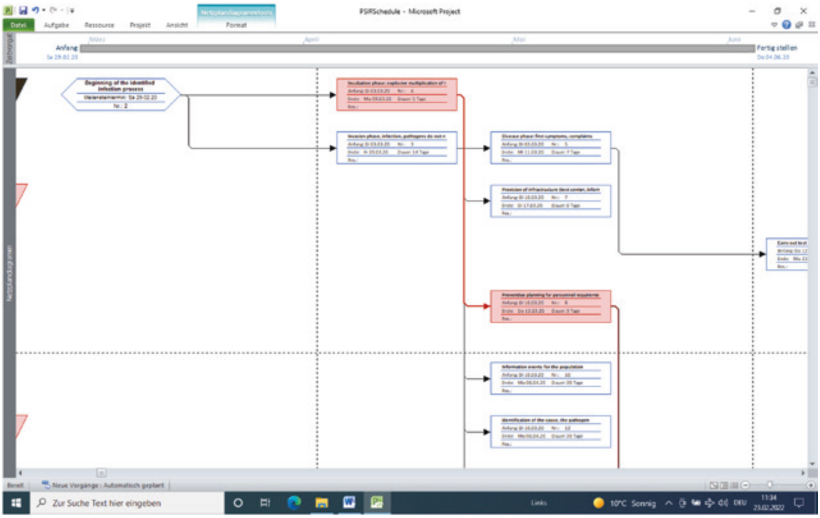


Fig. 10.21 Network plan technique. (Credit author)

According to the percentage of performance that emerges from the continuous data collection, the network planning system calculates the performance level, which, if it corresponds to the time limit, has no influence on the length of the duration of the respective activity and therefore has no effect on the subsequent activities.

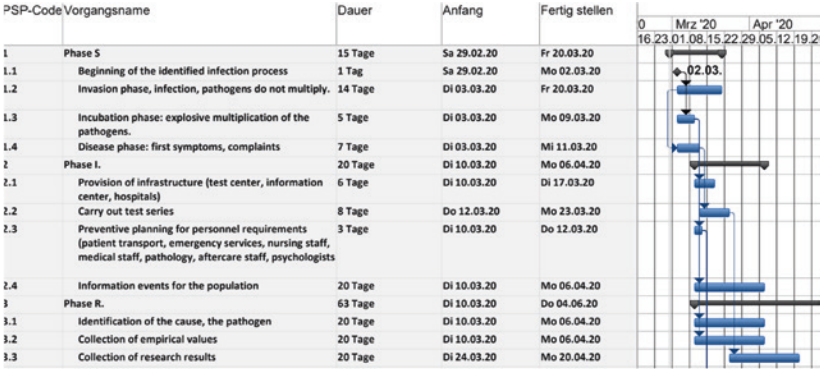
10.4.1 Phase Planning Bar Schedule

If, on the other hand, the current level of performance does not match the plan, the consequences affect the entire time structure, the schedule, excerpt from Fig. 10.22.

Jede Aktivität (Vorgangsname) kann mit Ressourcen belegt werden, die da sind:

planning

- the planned start
- the planned duration



PSP-Code	Vorgangsname	Dauer	Anfang	Fertig stellen
1	Phase S	15 Tage	Sa 29.02.20	Fr 20.03.20
1.1	Beginning of the identified infection process	1 Tag	Sa 29.02.20	Mo 02.03.20
1.2	Invasion phase, infection, pathogens do not multiply.	14 Tage	Di 03.03.20	Fr 20.03.20
1.3	Incubation phase: explosive multiplication of the pathogens.	5 Tage	Di 03.03.20	Mo 09.03.20
1.4	Disease phase: first symptoms, complaints	7 Tage	Di 03.03.20	Mi 11.03.20
2	Phase I.	20 Tage	Di 10.03.20	Mo 06.04.20
2.1	Provision of infrastructure (test center, information center, hospitals)	6 Tage	Di 10.03.20	Di 17.03.20
2.2	Carry out test series	8 Tage	Do 12.03.20	Mo 23.03.20
2.3	Preventive planning for personnel requirements (patient transport, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists	3 Tage	Di 10.03.20	Do 12.03.20
2.4	Information events for the population	20 Tage	Di 10.03.20	Mo 06.04.20
3	Phase R.	63 Tage	Di 10.03.20	Do 04.06.20
3.1	Identification of the cause, the pathogen	20 Tage	Di 10.03.20	Mo 06.04.20
3.2	Collection of empirical values	20 Tage	Di 10.03.20	Mo 06.04.20
3.3	Collection of research results	20 Tage	Di 24.03.20	Mo 20.04.20

Fig. 10.22 Excerpt of bar chart/schedule. (Credit author)

- the responsibility in person
- the planned costs
- the dependency on the predecessor or successor—activity

Rhythmic update at the time of the performance query

- actual start (actual start)
- the actual duration (actual duration)
- the actual costs
- the changed dependency on the predecessor or successor activity

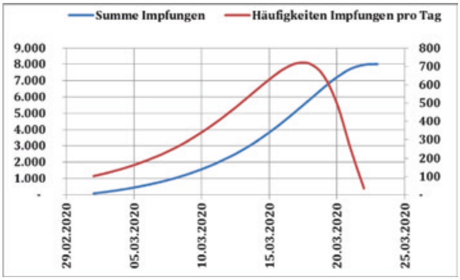
A look at Fig. 10.23 clarifies the connection to the planning process, which shows the time span in which 8,392 vaccinations were planned, which are shown in a table:

10.4.2 Target Figures for Totals and Frequencies

The combination of scheduling and the corresponding vaccination rates forms the basis for capacity planning for the resources that are necessary to practically implement the planned figures, Figs. 10.23a, b.

Datum	Summe Impfungen	Häufigkeiten Impfungen pro Tag
02.03.2020	88	103
03.03.2020	191	120
04.03.2020	310	140
05.03.2020	450	163
06.03.2020	613	189
07.03.2020	803	220
08.03.2020	1.023	255
09.03.2020	1.278	295
10.03.2020	1.574	341
11.03.2020	1.914	391
12.03.2020	2.306	447
13.03.2020	2.753	507
14.03.2020	3.260	569
15.03.2020	3.829	630
16.03.2020	4.459	682
17.03.2020	5.141	716
18.03.2020	5.858	714
19.03.2020	6.571	650
20.03.2020	7.222	498
21.03.2020	7.719	254
22.03.2020	7.974	36
23.03.2020	8.010	

a



b

Fig. 10.23 **a** Planning of the sum of the frequency, **b** frequency of vaccinations per day. (Credit author)

10.4.3 Actual Numbers for Totals and Counts

Let us now look at the actual status of the process in relation to the previous planning process in the event that the current start on February 27th, 2020 is 4 days later than planned, the current start is then March 3rd, 2020, (Fig. 10.24):

Target data

PSP-Code	Activity	duration	Calc. Start	Planned Start	Calc. Final	Completion date	Actual start	% completed
3.4.1.3	medication / vaccination	18 days	Do 27.02.20	Do 27.02.20	Mo 23.03.20	Mo 23.03.20	NV	0%

Actual data

PSP-Code	Activity	duration	Calc. Start	Planned Start	Calc. Final	Completion date	Actual start	% completed
3.4.1.3	medication / vaccination	18 days	Mi 04.03.20	Do 27.02.20	Fr 27.03.20	Fr 27.03.20	Mi 04.03.20	0%

Fig. 10.24 **a** Planning of the sum of the frequency, **b** frequency of vaccinations per day. (Credit author)

10.4.4 Update of Totals and Frequencies Related to Planning

In the course of the project management of an infection prevention project, it is necessary to observe and evaluate the measurement data, i.e. the number of cases and their number over time, i.e. their frequency. According to the rating that may say:

- the avoidance process is “under control”, the changes from the surveys of the vaccination rates in their frequency do not produce any changes and thus also not the parameter values,
- the avoidance process is “out of control”, the changes from the vaccination rate surveys in their frequency generate changes and thus also the parameter values, (Fig. 10.25).

This state of affairs is demonstrated as follows in the effects in which the beginning of the vaccination start date is delayed by 3 days, Fig. 10.24. The time shift can be recognized in a schedule by an offset between the planned date and the actual date for activity 3.4.1.3 medication/vaccination

The difference results from a time shift, so that the planned quantity structure of the plan figures for totals and frequencies is changed in such a way that the consequences for the vaccination rate and the associated avoidance effects are worsened Fig. 10.26a, b.

In the statistical surveys since the beginning of the COVD-19 pandemic, a percentage of deaths has developed that is close to 0.10% of the number of cases. Accordingly, the number of avoidable deaths develops proportionally.

10.4.5 Countermeasures for Deviations from Actual to Plan

To counteract deviations between planned dates and actual dates and the resources estimated with them—vaccination quotas—can help

Fig. 10.25 Appointment postponed by 4 days. (Credit author)

				0,10%
Sum Testdata	Sum Avoided if avoidance had started on 29.2.2020	future number of remaining infected	percent Avoided if avoidance started on 29.2.2020	percent avoided death
11.224	4.447	6.777	39,62%	4

a

				0,10%
Sum Testdata	Sum Avoided if avoidance had started on 4.3.2020	future number of remaining infected	percent Avoided if avoidance started on 4.3.2020	percent avoided death
11.224	3.131	8.093	27,90%	3

b

Fig. 10.26 Appointment postponed by 4 days, **a** previous vaccination rate, **b** worsening of the vaccination rate. (Credit author)

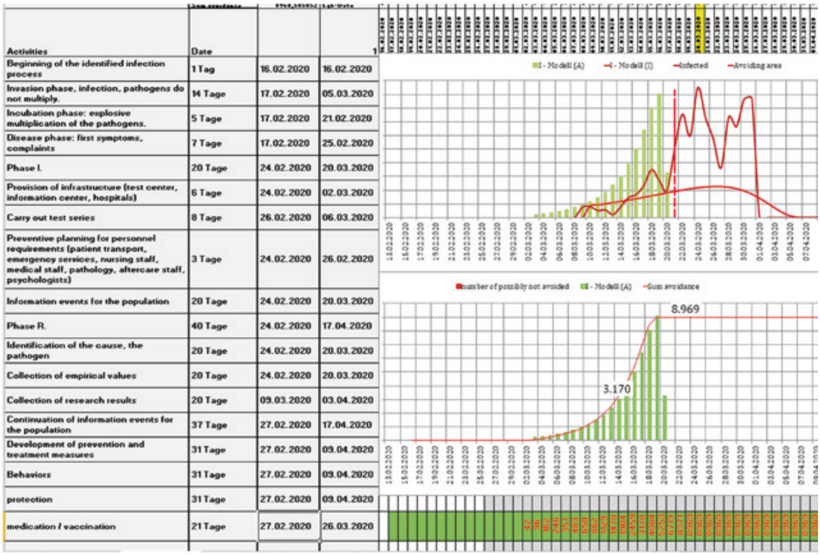
- the reduction of the planning time
- the rate of increase in resources—vaccination rates—in the time interval
- the reduction of the planned time and the rate of increase of the resources in the time interval

It is shown that the adjustment of spread and skew can contribute to the planned end and the planned vaccination rate can be met. The expected dates of the vaccination event are expected as follows:

Max	Standarddev	Skew-factor	Kurt-factor	Interval
1141	**731, 8**	**0,94%**	1,43	67,11,764,706
Start day	Interval duration	Final day	End date	
07.03.2020		16.05.2020	06.04.2020	

May the vaccination process be "caught up", a rate of increase in resources—vaccination quotas—in the time interval via the spread s on the parameter σ in the function can work towards a process change, which can subsequently make up for the delay, albeit under compressed circumstances, (Fig. 10.27).

Max	Standarddev	Skew-factor	Kurt-factor	Interval
1141	**200,0**	**0,60%**	1,43	67,1
Start day back			End date	
01.03.2020	6	07.03.2020	20.03.2020	



Activities	Date		
Beginning of the identified infection process	1 Tag	16.02.2020	16.02.2020
Invasion phase, infection, pathogens do not multiply.	14 Tage	17.02.2020	05.03.2020
Incubation phase: explosive multiplication of the pathogens.	5 Tage	17.02.2020	21.02.2020
Disease phase: first symptoms, complaints	7 Tage	17.02.2020	25.02.2020
Phase I.	20 Tage	24.02.2020	20.03.2020
Provision of infrastructure (test center, information center, hospitals)	6 Tage	24.02.2020	02.03.2020
Carry out test series	8 Tage	26.02.2020	06.03.2020
Preventive planning for personnel requirements (patient transport, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists)	3 Tage	24.02.2020	26.02.2020
Information events for the population	20 Tage	24.02.2020	20.03.2020
Phase R.	40 Tage	24.02.2020	17.04.2020
Identification of the cause, the pathogen	20 Tage	24.02.2020	20.03.2020
Collection of empirical values	20 Tage	24.02.2020	20.03.2020
Collection of research results	20 Tage	09.03.2020	03.04.2020
Continuation of information events for the population	37 Tage	27.02.2020	17.04.2020
Development of prevention and treatment measures	31 Tage	27.02.2020	09.04.2020
Behaviors	31 Tage	27.02.2020	09.04.2020
protection	31 Tage	27.02.2020	09.04.2020
medication / vaccination	21 Tage	27.02.2020	26.03.2020

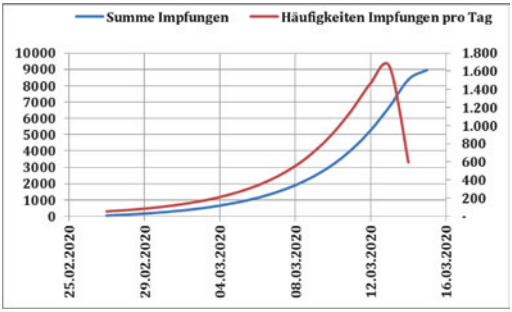
Fig. 10.27 Phase planning—adjustment within a statistical/probabilistic view. (Credit author)

The combination of scheduling and the corresponding vaccination rates forms the basis for capacity planning for the resources that are necessary to implement the planned figures in practice, (Figs. 10.28 a, b).

So once the metrics for planned infection prevention processes have been worked out, the metrics for the processes that are necessary for the preparation are based on them. The preparatory activities for the example "frequency of vaccinations per day" show that they are also allowed for capacity planning for all those that serve to fulfill the vaccination process.

Datum	Summe Impfungen	Häufigkeiten Impfungen pro Tag
27.02.2020	42	53
28.02.2020	96	67
29.02.2020	162	84
01.03.2020	246	105
02.03.2020	351	132
03.03.2020	483	167
04.03.2020	650	211
05.03.2020	862	268
06.03.2020	1129	340
07.03.2020	1470	434
08.03.2020	1904	555
09.03.2020	2459	712
10.03.2020	3170	914
11.03.2020	4084	1.169
12.03.2020	5253	1.466
13.03.2020	6719	1.652
14.03.2020	8371	597
15.03.2020	8969	

a



b

Fig. 10.28 Adaptation **a** planning of the sum of the frequency, **b** frequency of vaccinations per day. (Credit author)

11 Pre-phase Planning Supported by Network Planning Technology

The scheduled-capacitive planning and control of the aforementioned processes require timely and quantitatively appropriate preparation for the provision and implementation of the same. All activities listed below can be resource-dependent, so that each of them can be controlled in time and quantity in a manner as shown before. For this purpose, questions are added to each of the phases:

What amount in what time with what resources (personnel, material)?

Phase I

- Provision of infrastructure (test center, information center, hospitals)
- Carry out test series
- Preparedness planning for personnel requirements (ambulance transport, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists)
- Information events population

Phase R

- Identification of the cause, the pathogen
- Carry out test series
- Collection of empirical values
- Collection of research results
- Continuation of information events for the population
- Development of prevention and treatment measures

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1_11

11.1 Waves before the Wave

If it has been recognized that precautionary measures can curb an impending infection, then they are in the form of—prosaically called—"waves", although from a physical point of view the name is not consistent. Rather, the past of the "COVID-19 wave" has shown that not only the:

- "vaccination wave"

as well as the "mask wearing wave" and the "isolation wave"

in statistical terms as frequency curves very effectively in an overall "avoidance wave"

If the "vaccination wave" was primarily considered in this work, the same type of statistical, management-related consideration as described above applies to the other "waves"

This then also applies to the measures:

- behaviors/behavior: limit contacts, wash hands regularly, keep your distance, do not put your hands on your face, do not touch shopping carts, door handles and railings,
- protection/protection: wear a mask, limit travel, that were required, (Fig. 11.1).

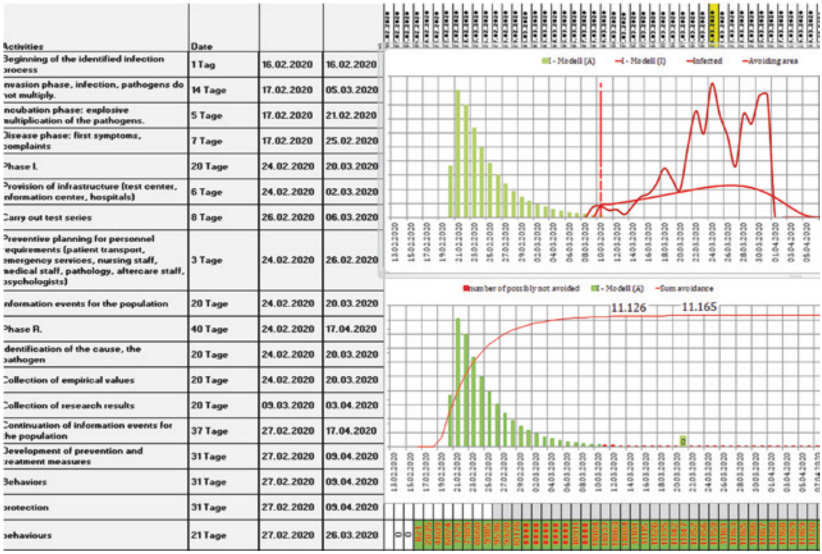
It becomes clear that not all of the measures mentioned above can be recorded in their frequency numbers in surveys, but that the amounts of precautionary resources for resources can at least be estimated if the exponential development becomes visible.

In this way, the "vaccination wave" can also be accompanied by a "protective wave of behavior", for the use of which material and personnel are required: the number of masks, the disinfectant liquids.

May the "protective wave of behavior" have a beginning, so obviously together with the announcement of an imminent "wave of infection".

According to preparatory measures, an initial occurrence of infection can be Fig. 11.2a, by

- Immediate measures = "mask wearing wave" and the "isolation wave" are reduced, Fig. 11.2b



Activities	Date		
Beginning of the identified infection process	1 Tag	16.02.2020	16.02.2020
nvasion phase, infection, pathogens do not multiply.	14 Tage	17.02.2020	05.03.2020
ncubation phase: explosive multiplication of the pathogens.	5 Tage	17.02.2020	21.02.2020
Disease phase: first symptoms, complaints	7 Tage	17.02.2020	25.02.2020
Phase I.	20 Tage	24.02.2020	20.03.2020
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Carry out test series	8 Tage	26.02.2020	06.03.2020
Preventive planning for personnel requirements (patient transport, emergency services, nursing staff, medical staff, pathology, aftercare staff, psychologists)	3 Tage	24.02.2020	26.02.2020
nformation events for the population	20 Tage	24.02.2020	20.03.2020
Phase R.	40 Tage	24.02.2020	17.04.2020
dentification of the cause, the pathogen	20 Tage	24.02.2020	20.03.2020
Collection of empirical values	20 Tage	24.02.2020	20.03.2020
Collection of research results	20 Tage	09.03.2020	03.04.2020
Continuation of information events for the population	37 Tage	27.02.2020	17.04.2020
Development of prevention and treatment measures	31 Tage	27.02.2020	09.04.2020
Behaviors	31 Tage	27.02.2020	09.04.2020
protection	31 Tage	27.02.2020	09.04.2020
behaviours	21 Tage	27.02.2020	26.03.2020

Fig. 11.1 Waves in front of the wave. (Credit author)

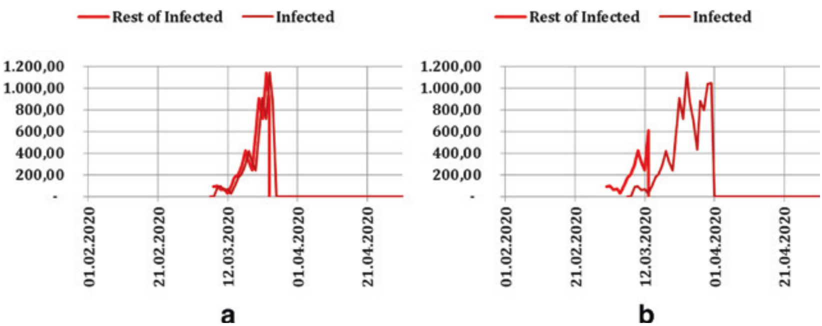

Fig. 11.2 **a** initial infection process, **b** immediate measures = "mask wearing wave" and the "isolation wave". (Credit author)

12 Summary

Quality management and project management are inextricably linked in project execution. This premise can also be transferred to infection management, because all processes and their activities that serve to prevent the spread are included in the definition

- the quality of resources.
- the use of resources of the same over time.
- the dependencies of the activities of a process in the required order are firmly connected to each other.

The processes can be observed effectively using quality management methods using the PSIR model shown, in which a forecast is projected by determining the initial infection speed using the logarithm, which indicates the subsequent exponential development. A "wave" can be avoided by creating a "wave before the wave" if the type of pathogen can be identified at an early stage.

In the previous chapters it is explained that infection processes can be systematically analyzed using the known methods from statistics, stochastics and probability theory. The case of a biological infection was considered in the present study.

The same way can be applied to other areas, meaning any infection process, including the digital one. The matter to be considered equally in all areas is the earliest possible detection of an "attack" on the organism to be protected, be it a biological, digital or organizational structure, of any kind, the frequency of which can increase rapidly at the beginning if this is not possible early and moderately recognized or even prevented. Risks of infection remain active as long as they are

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1_12

described, observed and measured, as long as they are not recognized and unopposed.

The modeling of an infection process uses the SIR—process. The methods described can gain from the fact that the parameters for skewness and kurtosis considered in the Eqbuibalalancedistribution (Eqb) take into account the actual skewness and steepness of an exponential expression of the frequency distribution, a good approximation to the asymmetric course over time.

What You Can Take in This *essential*

- The probabilistic SIR model (PSIR) should support the management preventives and treatment in time and amount

M. Hellwig, *The Probabilistic SIR Model (PSIR) in the Pandemic Process*, Springer essentials, https://doi.org/10.1007/978-3-031-31190-1

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Data collection case numbers and recovered:

https://npgeo-corona-npgeo-de.hub.arcgis.com/datasets/dd4580c810204019a7b8eb3e0b329dd6_0/explore?showTable=true;

https://github.com/jgehrcke/covid-19-germany-gae/blame/b9be1d8dfb3947b654edc9606cc6619dcdef9942/cases-rki-by-state.csv#L2;

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