



# Report on the study “Identifying default time values for LEP nursing interventions”

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## **Abstract**

Nursing interventions in Generation 3 of LEP Nursing are associated with default time values, e.g. 7 minutes for the LEP intervention “Performing lateral positioning”. A default time value is a standard time value specified for recording the time spent on an intervention, and can be changed. To update the default time values in a transparent manner based on large datasets so that the new values can be included in the release management process for the next Nursing version, a study was conducted with the assistance of 20 healthcare organisations in Germany and Switzerland which volunteered to participate.

After inclusion criteria were applied, the number of LEP interventions with time values delivered by the 20 hospitals was reduced from 564 to 516. The results are based on approximately 62.2 million LEP interventions, performed by 15,202 registered nurses for 213,051 patients. In total, default time values could be determined for 515 LEP interventions from Nursing version 3.4.1, i.e. 89.6% of the 575 total interventions. In these 20 hospitals, 60 LEP interventions were either never performed (12 interventions) or fewer than 30 times (48 interventions).

As part of the LEP release management process, the default time values thus determined are systematically incorporated into the next version of LEP Nursing. The results can then be used as default values in software implementations of LEP. The default values are reviewed at least every three years as part of the LEP release management process.

For healthcare organisations and software companies that wish to begin using the newly determined default time values and integrate them into their LEP applications before the values are implemented as part of the regular LEP release management process, a list of the default time values determined for the relevant LEP Nursing versions (3.1.0, 3.2.0, 3.3.1 and 3.4.1) can be provided upon request.

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## 1 Introduction

LEP Nursing 3 is a classification system for nursing interventions (Baumberger, Hieber, et al., 2016). It is used in electronic patient documentation and for recording services at some 700 healthcare organisations in Germany, Austria, Italy and Switzerland. Following the definition set by the WHO, an LEP nursing intervention is an action that is taken on behalf of a person or the general populace in order to evaluate health, functions or states of health, and to modify or improve them (WHO-FIC Family Development Committee, 2012).

For work planning purposes and for statistical analyses of the time spent on nursing care, time values can be recorded for LEP interventions (LEP-IIDs, IIDs), e.g. 7 minutes for the intervention “Performing lateral positioning”. In the current version, LEP Nursing 3.4.1, a default time value is assigned to each intervention (Baumberger, Hieber, et al., 2016, p. 32–33, 160). In LEP, a default value is a standard time value specified for recording the time spent on a particular intervention (initial, baseline, or standard value), and this value can be changed. In other words, the difference to a traditional normative time value or reference time value is that a default value can be changed.

A given LEP intervention is either assigned a default time value or not. In the ideal case, time values are handled as follows.

If an LEP intervention

- has a time value assigned to it, then
  - the service providers use the specified time value in their documentation, or
  - the service providers modify the specified time value in their documentation.
- has no time value assigned to it, then
  - the service providers enter a time value in their documentation, or
  - the healthcare organisation specifies a time value and the service providers either use or modify this value.

The most recent large-scale review of default time values was conducted in 2016 (Baumberger, Bürgin, & Hieber, 2016). They are continuously reviewed and modified if necessary as part of LEP release management. In the current LEP version, there are no default time values for 119 out of 575 LEP IIDs with case assignment, or about 20.7% (Nursing version 3.4.1, aggregation level four of the classification, variable type D; excludes IIDs for services without case assignment and services otherwise specified).

### 1.1 Research questions

1. What distribution of default time values is observed for the individual nursing interventions?
2. Can default time values be identified for all nursing interventions?

## 1.2 Structure of the report

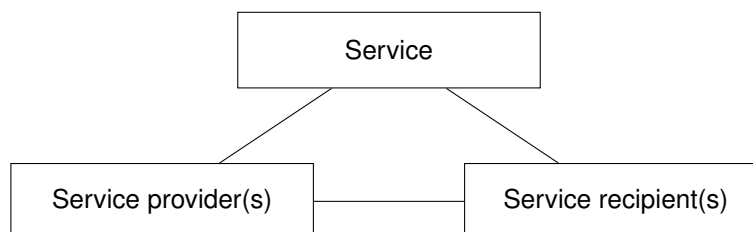
The document is structured as follows: Section 2 describes the data collection design, specifies the variables recorded, and explains how the data were prepared. Section 3 explains the statistical methods used to calculate quantiles in the distribution of minute values for individual LEP nursing interventions, including references to the software applications used. Section 4 presents the resulting quantiles and compares the hospitals to one another, and the quantiles are contrasted for evaluation purposes with those resulting from alternative methods. Finally, Section 6 discusses how to incorporate the results into practical uses of LEP.

## 2 Data

### 2.1 Study design and data

For this study, detailed data were collected from 20 hospitals<sup>1</sup> in Germany and Switzerland. The data collected include information that can be divided into three types: (i) data about the service itself, i.e. information about the type of service (e.g. “performing arterial blood collection”), the time spent, and the time and place where the service was provided, (ii) information about the service recipient<sup>2</sup> (case, patient), and (iii) information about the service provider (registered nurse). Figure 1 presents the data model.

Figure 1: Data model for LEP interventions.



The data collected therefore indicate what services were provided where, for whom and by whom. Table 1 lists the features or variables that were actually recorded. Variables 2–10, 13 and 14 provide information about the service. Variable 1 is a feature of the case (service recipient). Variables 11 and 12 are features of the registered nurses (service providers).

<sup>1</sup>Some hospitals are divided into multiple sites. In this study, such sites are treated as independent hospitals.

<sup>2</sup>Male- and female-specific expressions are sometimes used when referring to people in this text. Such expressions should be understood to include the other gender and non-binary people as well.

Table 1: Features

	Abbreviation	Description
1	FID	Anonymous service recipient identification number
2	Datum	Date when the LEP intervention was provided
3	BID	Anonymous identification number for the hospital providing the service or place of service
4	IID	Content number of the LEP intervention
5	SID	Structure number of the LEP intervention (only needed if IID is unknown)
6	LEP-Vers	The LEP version
7	LEP_Min	Time spent in minutes (LEP minutes)
8	Anz_PP	Number of healthcare professionals involved in performing the intervention (usually 1)
9	Fachgeb	Areas of specialisation from LEP, e.g. 300 = Gynaecology/Obstetrics, general
10	Station	Ward type from LEP, e.g. 8 = Postpartum/Gynaecology
11	Personal_ID	Anonymous service provider identification number
12	PersKat	Staff category from LEP, e.g. 211 = certified registered nurses
13	oper_date	Time when the intervention was performed
14	LEP-Anz	Number of interventions (usually 1)

The variables for areas of specialisation (Fachgeb), ward (Station) and staff category (PersKat) in Table 1 are categories defined by LEP AG. The individual categories can be provided upon request.

For service recipients (patients) in particular, additional features like gender or age could have been collected here. However, such features are not our primary interest here. The case identification number (FID) is relevant because it can be used to statistically record and correct heterogeneities among patients. A similar notion applies for the service providers, for whom features like staff category were recorded. Another reason for this is that it was known from the outset that individual hospitals would not be able to provide the staff identification number (Personal\_ID) for privacy reasons. For the analysis, registered nurses' features were used to construct the staff identification number. It is important to note that the identification numbers for both patients and registered nurses are anonymised sequence numbers.

Table 2 presents three example data sets for illustration purposes. The first two refer to the same case (FID), the same intervention (IID), and two different registered nurses (Personal\_ID).

Table 2: Example data sets

	FID	Datum	BID	IID	SID	LEP-Vers	LEP_Min	Anz_PP	Fachgeb	Station	Personal_ID	PersKat	oper_date	LEP-Anz
1	500016	2021-01-31	Z	I_22876	1.5.1.9	3.4.1	15	1	300	8	1000	211	08:15	1
2	500016	2021-01-31	Z	I_22876	1.5.1.9	3.4.1	20	1	300	8	1001	215	12:08	1
3	500016	2021-01-31	Z	I_23100	1.3.1.20	3.4.1	15	2	300	8	1000	211	09:42	1

## 2.2 Data collection

The data were collected on the basis of a descriptive design (Burns, Grove, & Gray, 2014). The data providers are the hospitals, which participated voluntarily. The data include LEP interventions performed and documented in the period between 1 April and 30 September 2021. The only hospitals considered for inclusion in the study were those where LEP Nursing 3 has been in production use since at least 1 April 2020 and where the technical capabilities were in place to provide the necessary data. A total of 96

hospitals were identified and contacted as potential participants. Of these, 20 hospitals (20.8%) took part in the study. There was no requirement for complete participation with regard to data collection, and the hospitals were therefore not asked any questions on this point. The data were delivered by the hospitals in electronic form by the deadline of 14 December 2021. The hospitals were anonymised for the analysis phase.

The data are imbalanced with regard to the number of records per patient and per registered nurse. As such, the number of records varies between patients, between registered nurses, and between hospitals. Statistical methods were used to adjust for these imbalances, see Section 3.

*Table 3: Data collection by hospital. Figures refer to the delivered data and the processed data.*

Hospital	Country	Interventions delivered	Interventions processed	Patients processed	IIDs processed	Registered nurses processed
B	CH	25,000	21,759	179	157	303
C	CH	9,356,308	8,950,026	21,631	389	2,406
F	CH	1,561,554	1,225,921	6,396	382	520
J	CH	1,464,185	981,233	8,298	206	3
K	CH	3,734,399	2,537,972	12,093	391	935
N	CH	6,676,252	6,464,157	17,968	304	1,809
O	CH	992,310	885,131	2,980	381	275
S	CH	1,210,304	967,080	15,529	430	399
A	DE	691,164	691,163	3,380	217	219
D	DE	989,609	989,520	4,380	321	385
E	DE	3,447,401	3,446,926	14,743	400	959
G	DE	1,025,798	952,250	6,756	419	1,305
H	DE	74,457	74,452	892	206	29
I	DE	115,290	115,279	1,302	213	103
L	DE	7,783,512	6,505,318	37,951	441	1,795
M	DE	21,342,096	18,868,885	26,424	424	945
P	DE	1,693,922	1,693,917	10,749	277	535
Q	DE	3,433,768	3,126,479	8,700	402	723
R	DE	2,951,964	2,628,689	2,409	348	636
T	DE	1,048,575	1,046,779	10,291	323	918
Total		69,617,868	62,172,936	213,051	516	15,202

Table 3 provides an overview of the data delivered by each hospital. Of the 20 hospitals, 8 are located in Switzerland (CH) and 12 in Germany (DE). The numbers of records, patients, registered nurses and LEP nursing care interventions shown in the table refer to the data after processing, cf. Section 2.3. The IIDs refer to LEP versions  $\geq 3.1.0$ . The processed data cover 516 IIDs in total, of which 515 could be assigned to IIDs in LEP version 3.4.1.

The identification numbers for patients (FID) and registered nurses (Personal\_ID) were collected in an anonymous manner. The hospitals were provided with instructions on this process. To ensure anonymity, these identification numbers were replaced with a random sequence during data processing, see Section 2.3.

For five of the 20 participating hospitals, the data collection period did not align with the specified period of 1 April to 30 September 2021. At hospital B, data were missing for the last week of September; hospital F only delivered data for just under a month, from 1 to 24 November 2021; hospital K delivered data for February 2021 only; hospital Q delivered data for almost 11 months, from 1 January to 24 November; and

hospital T delivered data for just 3 months, from 1 July to 30 September 2021. However, no adjustments were made in the analyses to adapt to these differences in data collection periods between hospitals.

### 2.3 Data processing

The data were cleaned and transformed for analysis:

1. As a first step, the data were entered into a computer and reviewed separately for each hospital. The hospitals were contacted on any points that were unclear.
2. The records were then filtered according to various criteria. Only LEP interventions from LEP Nursing  $\geq$  3.1.0, with case assignment, type D, were included.<sup>3</sup>
3. Records with 0 LEP minutes were removed since they were meaningless in terms of their content.
4. Calculations were only performed for IIDs for which at least 30 records were available.<sup>4</sup>
5. The identification numbers for the hospitals, patients and registered nurses were replaced by a random sequence.
6. To make the results easier to read, codes like the IID number etc. were replaced using master data and associated labelling.

As seen in Table 3, the cleaning process reduced the data from 69,617,868 records to 62,172,936, and reduced the number of IIDs by 69 (all versions  $\geq$  3.1.0). Of the 69 IIDs thus eliminated, 21 were services without case assignment.

## 3 Data analysis methods

The distribution of time values for individual LEP IIDs is characterised using quantiles. A calculated quantile is an estimate of a time value that a predetermined percentage of the data falls below. For example, the median is the 50% quantile, and a value of 10 minutes here would mean that 50% of the values fall between 0 and 10 minutes. Our analysis makes reference to the 0% (minimum), 25% (first quartile), 50% (median), 75% (third quartile), and 100% (maximum) quantiles, and in some cases to 2.5% and 97.5% as well. Because the minimum and maximum are not robust statistical indicators, they should be interpreted with great caution. The median or 50% values are adopted as default time values. The advantage of using the median rather than the traditional mean is that the former is robust with regard to outliers.

Figure 2 shows the distribution of LEP minutes for the most commonly occurring IID, I\_22835 “Providing / clearing away a meal”, on the original scale in minutes and on the log-minutes scale. While this distribution is different for each LEP IID, this figure includes certain features that are frequently observed:

<sup>3</sup>Excluding: (i) Services without case assignment, e.g. “Managing medications/infusions”, (ii) Interventions otherwise specified, e.g. “Movement, otherwise specified” (included from LEP Nursing version 3.3 onward), (iii) Other interventions, e.g. “Other interventions relating to mobilisation” (included in versions 3.0 to 3.2) and (iv) placeholder items, e.g. “AE3 Mobilisation” (included from Nursing version 3.3 onward).

<sup>4</sup>In the authors’ experience, calculations for fewer than 30 records are not sufficiently robust.

The LEP minutes are generally skewed to the right and show outliers at the high end (at 118 minutes in this case), and there is often an extreme modal value<sup>5</sup> (5 minutes in this example). The modal value of 5 minutes corresponds exactly to the current default time value for IID I\_22835. Using a log transformation generally produces a more symmetrical distribution of time values around the mode than with the original scale.

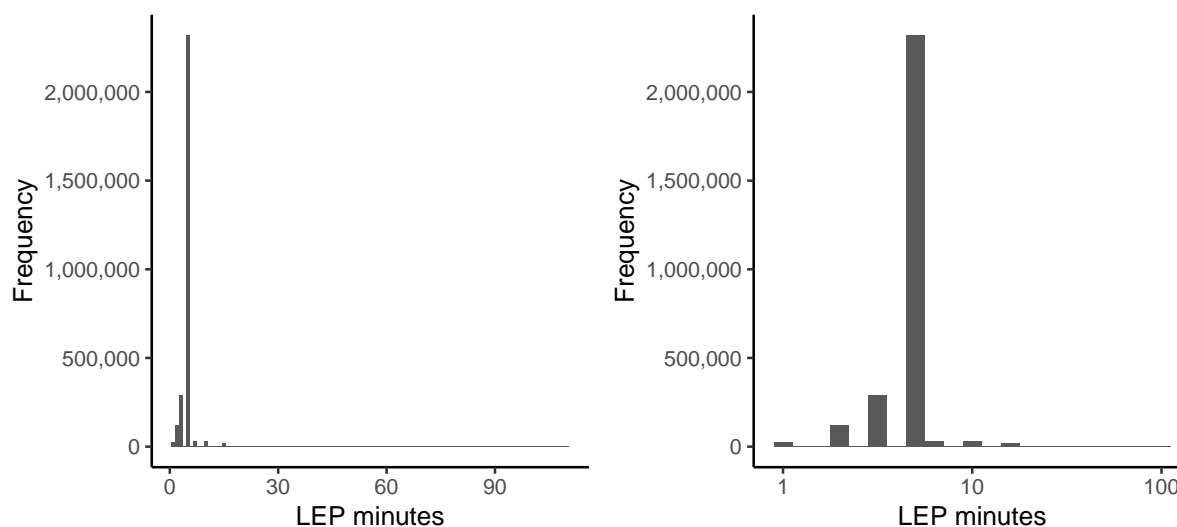


Figure 2: Distribution of LEP minutes for IID I\_22835, “Providing / clearing away a meal”, on the original scale in minutes and on the log-minutes scale

Due to the imbalanced nature of the collected data (cf. Section 2.2) and outliers, a correction of the time values in the raw data is needed. This correction is based on a regression model, explained below. The goal of this method is to factor out intra-individual heterogeneities between patients and registered nurses. The final quantiles are based on these corrected LEP minutes, and not on the original LEP minutes.

**Example of heterogeneities between patients** For the LEP IID “Showering”, the time spent may be greater for older patients than for younger patients. In this case, if there are five time values for an older patient and 10 time values for a younger patient (to take a simplified example), then using standard methods will cause us to underestimate the time spent. We can correct for this by taking a few minutes away from the older patient, and adding a few minutes for the younger patient.

For analysis purposes, (i) the recorded time values are *corrected*, and (ii) the median and other quantiles are calculated from the corrected time values. To perform this correction, the original time values are multiplied by a factor to take the effects of patients’ or nurses’ individual behaviour into account.

The data correction procedure is described in Section 3.1 below. A summary of the method with graphs is provided at the end of the section (Figures 3-5) for readers who are not interested in the methodological details.

<sup>5</sup>The modal value or mode is the most frequently occurring value. For present purposes, an extreme modal value means that the frequency of the modal value is many times greater than the frequency of the other values.



### 3.1 Correcting the time values

For analysis purposes, linear regression is used to correct the time values (LEP minutes) for case- and nurse-specific deviations from average behaviour. Such deviations from average behaviour have a particularly strong influence on the distribution of LEP minutes if patients or nurses with large deviations also have a large number of interventions. The correction procedure consists of multiplying the LEP minute values originally recorded by a correction factor.

The correction factor is calculated on the basis of a linear regression model. In this model, the logarithmically transformed LEP minute values are used as the target variables and the hospital, patient and nurse are used as the explanatory variables. The justification for the logarithmic transformation is that experience shows that the residuals more closely align with a normal distribution with the transformation than without it. In addition, special boundary conditions (model contrasts) are used so that the correction factor relates to a certain overall mean value. Table 4 defines the variables used.

Table 4: Variable definitions

Variable	Description
$Y$	$y_i$ are the LEP minutes for the $i$ th LEP nursing intervention, $i = 1, \dots, N$
$X_{1b}$	Indicator variable with $x_{i,1b} = 1$ si le $i$ th record is from hospital $b$ , $b = 1, \dots, B$ , otherwise $x_{i,1b} = 0$
$X_{2bj}$	Indicator variable with $x_{i,2bj} = 1$ if the $i$ th record is from case $j$ , $j = 1, \dots, J_b$ and hospital $b$ , otherwise $x_{i,2bj} = 0$
$X_{3bk}$	Indicator variable with $x_{i,3bk} = 1$ if the $i$ th intervention is performed by nurse $k$ , $k = 1, \dots, K_b$ and hospital $b$ , otherwise $x_{i,3bk} = 0$

Based on these definitions, the linear regression model used for a particular LEP IID can be described as follows:

$$\mathcal{M} : \log(y_i) = \beta_0 + \sum_{b=1}^B \beta_{1b} x_{i,1b} + \sum_{b=1}^B \sum_{j=1}^{J_b} \beta_{2bj} x_{i,2bj} + \sum_{b=1}^B \sum_{k=1}^{K_b} \beta_{3bk} x_{i,3bk} + \varepsilon_i, \quad \varepsilon_i \stackrel{i.i.d.}{\sim} N(0, \sigma) \quad (1)$$

with boundary conditions

$$\sum_{b=1}^B N_b \beta_{1b} = 0, \quad \sum_{j=1}^{J_b} \beta_{2bj} = 0 \quad \forall b, \quad \sum_{k=1}^{K_b} \beta_{3bk} = 0 \quad \forall b \quad (2)$$

where  $N_b = \sum_{j=1}^{J_b} \sum_{k=1}^{K_b} 1 \left( \mathbf{x}_{2bj}^T \cdot \mathbf{x}_{i,3bk} > 0 \right)$  is the number of combinations of patients and nurses observed in hospital  $b$ .

The parameters of model  $\mathcal{M}$  (Eq. 1) can be interpreted as follows:

- $\beta_0$ : Overall mean of the log-transformed LEP minutes, calculated as a weighted mean of the mean log-transformed LEP minutes for each hospital.

- $\beta_{1b}$ : Deviation of the mean log-transformed LEP minutes of hospital  $b$  from the overall mean  $\beta_0$ . As a result of the boundary conditions  $\sum_{j=1}^J \beta_{2bj} = 0$  and  $\sum_{k=1}^K \beta_{3bk} = 0$  (so-called sum contrasts), the mean log-transformed LEP minutes for hospital  $b$ , i.e.  $\mu_0 + \beta_{1b}$ , corresponds to the unweighted mean of the model's predictions for all  $J_b \times K_b$  possible combinations of patients and registered nurses within hospital  $b$  (including combinations that were not observed). As a result of the boundary conditions, each combination of patient  $j$  and registered nurse  $k$  has the same weight, and frequently occurring patient-nurse combinations are thereby balanced out.
- $\beta_{2bj}$ : Deviation of patient  $j$  and hospital  $b$  from the mean log-transformed LEP minutes of hospital  $b$ ,  $\beta_0 + \beta_{1b}$
- $\beta_{3bk}$ : Deviation of registered nurse  $k$  and hospital  $b$  from the mean log-transformed LEP minutes of hospital  $b$ ,  $\beta_0 + \beta_{1b}$

**Estimation** The model  $\mathcal{M}$  (Eq. 1) is estimated using separate models for each hospital  $b$ :

$$\mathcal{M}_b : \log(y_i) = \beta_{0b} + \sum_{j=1}^{J_b} \beta_{2bj} x_{i,2bj} + \sum_{k=1}^{K_b} \beta_{3bk} x_{i,3bk} + \varepsilon_i, \quad \varepsilon_i \stackrel{i.i.d.}{\sim} \text{N}(0, \sigma_b), \quad \forall i \in \{I | x_{I,1b} = 1\} \quad (3)$$

The missing coefficients  $\beta_0$  and  $\beta_{1b}$ ,  $b = 1, \dots, B$  of  $\mathcal{M}$  (Eq. 1) are subsequently estimated as:

$$\beta_0 = \frac{1}{\sum_{b=1}^B N_b} \sum_{b=1}^B N_b \beta_{0b} \quad (4)$$

$$\beta_{1b} = \beta_{0b} - \beta_0 \quad (5)$$

$\beta_0$  is calculated as the weighted mean of the hospital mean values  $\beta_{0b}$ , since the number of interventions varies widely between hospitals and an unweighted calculation would therefore be unstable. For the weight, we use  $N_b$ , the observed number of patient-nurse combinations at hospital  $b$ :

$$N_b = \sum_{j=1}^{J_b} \sum_{k=1}^{K_b} 1(x_{2bj}^T x_{i,3bk} > 0) \quad (6)$$

As a result, the hospitals with many patients and nurses, and in which patients are cared for by the greatest number of different nurses, are assigned a high weight. This weighting is somewhat arbitrary, but the authors consider it appropriate.

The estimation of the individual models  $\mathcal{M}_b$  (Eq. 3) was calculated using the weighted least squares method (par ex. Baltagi, 2011, p. 223). The effect of the weighted used is that outliers (very low or very high LEP minute values) have a smaller influence on the estimated parameters, and were calculated with the `glmrob()` function from the **robustbase** R package (Maechler et al., 2022). The calculation consists of estimating a robust linear regression model on the log-transformed LEP minutes for each

LEP IID, with no explanatory variables. A by-product of this estimation is the generation of “Robustness Weights” that were used for estimating the individual models  $\mathcal{M}_b$ .

Since the number of interventions for certain LEP IIDs and hospitals was in the millions, it was impracticable to use the standard R function `lm()` to estimate the models  $\mathcal{M}_b$  (Eq. 3). Instead, we used our own function that solves the weighted least squares method using the Frisch–Waugh–Lovell theorem (par ex. Baltagi, 2011, Chap. 7.3).

Using the estimated parameters for  $\mathcal{M}$  (Eq. 1), the corrected LEP minutes are calculated as follows. Where  $\hat{y}_i$  is the value for  $y_i$  as modified by  $\mathcal{M}$ ,

$$\log(\hat{y}_i) = \beta_0 + \sum_{b=1}^B \beta_{1b} x_{i,1b} + \sum_{b=1}^B \sum_{j=1}^J \beta_{2bj} x_{i,2bj} + \sum_{b=1}^B \sum_{k=1}^K \beta_{3bk} x_{i,3bk}. \quad (7)$$

The corrected value  $\tilde{y}_i$  is calculated as:

$$\tilde{y}_i := \exp(\beta_0 + \log(y_i) - \log(\hat{y}_i)) = y_i \cdot \frac{e^{\beta_0}}{\hat{y}_i} \quad (8)$$

This correction can be interpreted either as a reverse transformation of the overall mean value  $\beta_0$  plus the model residuals, or simply as a multiplication of the original LEP minutes  $y_i$  by a factor calculated with model  $\mathcal{M}$ . It is worth mentioning that the geometric mean of corrected LEP minutes,  $\tilde{y}_i$ , corresponds precisely to the value  $e^{\beta_0}$ .

In order to compare different hospitals, the calculations in Section 4.1.1 use the corrected LEP minutes for each hospital. The adjusted value for  $y_i$  is taken from the corresponding model  $\mathcal{M}_b$  (Eq. 3)

$$\log(\hat{y}_i^{(b)}) = \beta_{0b} + \sum_{j=1}^J \beta_{2bj} x_{i,2bj} + \sum_{k=1}^K \beta_{3bk} x_{i,3bk}, \quad \forall i \in \{I | x_{i,1b} = 1\} \quad (9)$$

and the corrected LEP minutes for each hospital,  $\tilde{y}_i^{(b)}$ , are then calculated as

$$\tilde{y}_i^{(b)} := \exp\left(\beta_{0b} + \log(y_i) - \log(\hat{y}_i^{(b)})\right) = y_i \cdot \frac{e^{\beta_{0b}}}{\hat{y}_i^{(b)}} \quad (10)$$

**Deviations in the calculation procedure** The calculation procedure deviates from the approach described above in two situations:

1. **No variation in LEP minutes:** In some cases, all LEP minute values from a given hospital for a given LEP IID are identical. For numerical reasons, this sometimes led to implausible corrections. Therefore, model  $\mathcal{M}_b$  (Eq. 3) was not calculated if 95% of the LEP minute values were identical. Instead,  $\hat{\beta}_{0b}$  was replaced by the weighted mean  $\frac{1}{\sum_i w_i} \sum_i w_i \log(y_i)$ , and  $\hat{\beta}_{2bj}$  and  $\hat{\beta}_{3bk}$  were replaced

by 0.

2. **Patients/nurses with few interventions:** Patients and/or nurses have very few interventions for certain LEP IIDs. Since this led to problems in identifying parameters or other numerical problems in the estimation of model  $\mathcal{M}_b$  (Eq. 3), such patients and nurses were merged together. To do this, we applied the following (arbitrary) procedure separately by LEP IID and hospital:

- (a) Merge all patients with very few interventions (e.g. fewer than 3) into one fictitious patient.
- (b) Merge all nurses with very few interventions (e.g. fewer than 3) or a small number of different patients treated (e.g. the nurse's interventions almost all involved the same patient) into one fictitious nurse.

Details of these merges can be provided upon request.

Both of these deviating calculation methods were used frequently, see Section 4.

**Overview** The following figures (Fig. 3-5) provide a simplified description of the method. Figure 3 shows nine fictitious LEP minute values which refer to a certain LEP IID (e.g. “Performing lateral positioning”), and which for the sake of simplicity are all from the same hospital. The colours and symbols indicate that these LEP minute values are associated with two nurses and three patients. The data are imbalanced: Patient 1 has five LEP minute values, while Patients 2 and 3 have only two LEP minute values each. The horizontal line represents the median, i.e. the fifth-largest LEP minute value.

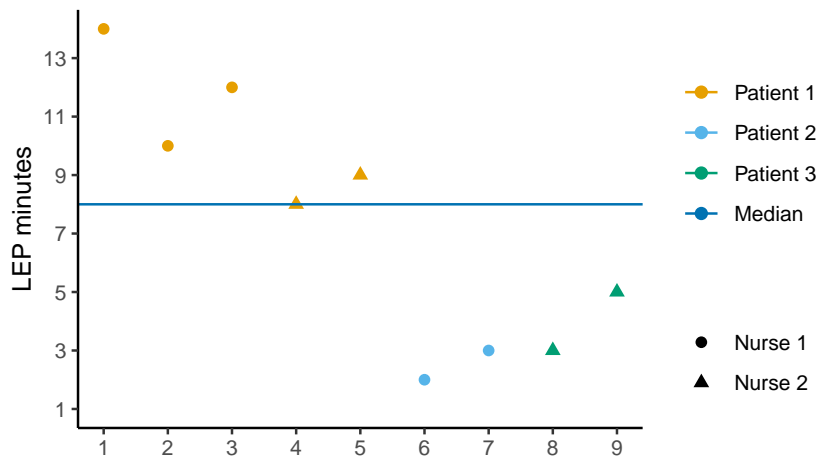


Figure 3: Method example: Regression model for logarithmically transformed LEP minutes.

The result of the linear regression model used to correct the LEP minute values is presented in Figure 4. The correction is performed on the logarithmic scale of LEP minutes, since the LEP minutes typically skew strongly to the right and since the regression model therefore works better when a logarithmic transformation is used. In the regression model, the log-transformed LEP minutes are predicted with additive effects for the patients and nurses. These predictions are visually represented by the discontinuous horizontal lines, and the model residuals by the vertical lines. The correction consists of subtracting the patient and nurse effects from the log-transformed LEP minutes so that the corrected LEP minutes correspond to the

corrected mean value (continuous red line) plus the residuals. The corrected mean value corresponds to the mean of the predicted LEP minutes for all possible combinations of patients and nurses.

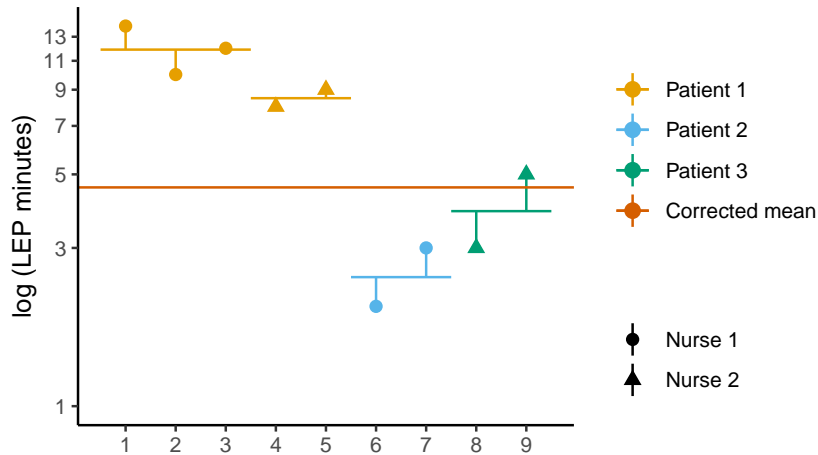


Figure 4: Method example: Correction of logarithmically transformed LEP minutes.

For the final calculation of default time values, the corrected LEP minutes are reverse-transformed back to the minutes scale. Figure 5 shows the corrected LEP minute values for our illustrative example, along with the median of the original LEP minutes (continuous blue line, see also Figure 3) and the reverse-transformed median and mean of the corrected LEP minutes (continuous red and pink lines). The latter two lines are practically right on top of one another, which does not necessarily have to be the case. In the corrected LEP minutes, there are no visible effects with regard to patients and nurses. The median of the corrected LEP minute values is lower than the median of the original LEP minute values, because Patient 1 exhibited a strong effect and because that patient was weighted less heavily in the corrected calculation.

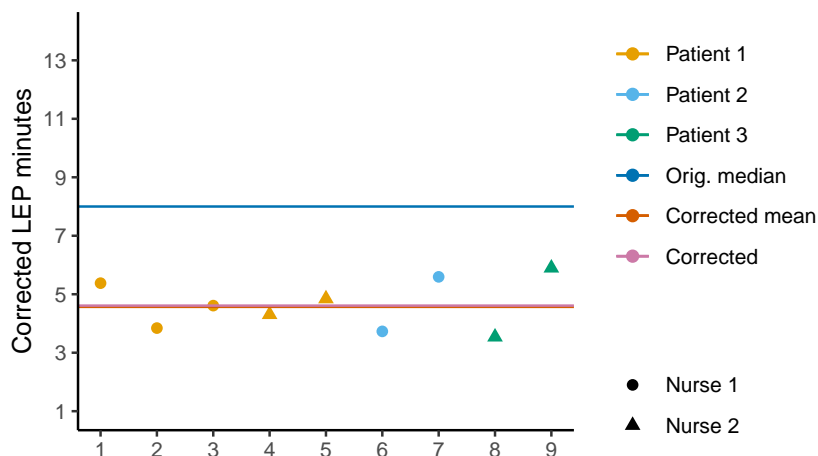


Figure 5: Method example: Median of corrected LEP minutes.

The correction is applied individually by LEP IID, allowing patient and nurse effects to vary freely between LEP IIDs.

The above summary ignores certain aspects of the actual correction procedure, notably how we deal with outliers and hospital effects. For a precise description, see the previous section.

### 3.2 Rounding the results

Correction of time values (Section 3.1) generally produces floating-point values. The results (medians, quantiles) are rounded as follows:

1. Medians/quantiles over 0.5 are rounded to the nearest whole number.
2. Medians/quantiles between 0 and 0.5 are rounded to 1.

### 3.3 Software

The data analysis was implemented with the R statistical software environment R (R Core Team, 2022). For certain methods, additional packages had to be used: Robust regression models were calculated with the `glmrob()` function from the **robustbase** package (Maechler et al., 2022). To deal with large volumes of data, the **data.table** (Dowle & Srinivasan, 2021) and **Matrix** (Bates, Maechler, & Jagan, 2022) packages were used when possible. The **xtable** package (Dahl, Scott, Roosen, Magnusson, & Swinton, 2019) was used for tabular illustrations.

### 3.4 Notes on interpreting the calculations

As exemplified earlier in Figure 2, the LEP minute values for a given IID often have extreme modal values. This is consistent with the survey results, which show that when recording interventions, LEP minute values are only changed if the actual time spent deviates considerably from the default time value (see Figure 12). For this reason, the calculated medians were often identical with the current default time values. In general, a calculated median cannot be interpreted as the median of independent time measurement values, but rather as the current default time value plus some potential deviation due to the fact that the actual time spent often strongly deviated from the default time value in a particular direction (upward or downward), or because the hospitals use their own, significantly different default time values. While calculating the default time values using data from independent time measurements would be desirable, it hardly seems feasible in practice.

## 4 Results

The data analysis focuses on the first research question, namely: What distribution of time values is observed for individual LEP nursing interventions (LEP IIDs)? Only those LEP IIDs that were included in the study according to the criteria in Section 2.3 (e.g. LEP Nursing  $\geq 3.1.0$ , only services with case assignment) have been taken into consideration here. Results for individual IIDs are presented as examples.

The following results with regard to the distribution of LEP minutes are based on the time value correction procedure described in Section 3.1. A total of 516 models  $\mathcal{M}$  (Eq. 1) by LEP IID and 6,631 models  $\mathcal{M}_b$  (Eq. 3) by LEP IID and hospital were calculated. For 4,126 of the 6,631 models by LEP IID and hospital, the patient and nurse effects  $\beta_{2bj}$  and  $\beta_{3bk}$  were not estimated, since the LEP minutes varied too little. Among the 2,505 models by LEP IID and hospital for which the patient and nurse effects  $\beta_{2bj}$  and  $\beta_{3bk}$  were estimated, certain patients or nurses were merged together in 1,414 models because they had too few interventions or because the nurses' interventions almost all involved the same patient.

#### 4.1 Distribution of time values

Table 5 presents examples of a few quantiles (minimum, 2.5% quantile, 25% quantile, median, 75% quantile, 97.5% quantile and maximum) in the distribution of corrected LEP minutes for 10 selected LEP interventions. The number of measured interventions is also listed in the table.

*Table 5: Quantiles of corrected LEP minutes by LEP nursing intervention.*

IID	Description	N	Min	2.5%	25%	Median	75%	97.5%	Max
I_22657	Performing a full body wash	208,649	1	20	22	22	22	34	234
I_22764	Dispensing guidance/instruction	304,090	1	4	5	5	5	9	107
I_22801	Measuring body temperature	1,513,510	1	2	2	2	2	2	34
I_22835	Providing / clearing away a meal	2,842,643	1	4	5	5	5	5	71
I_22848	Monitoring medication intake	1,389,371	1	2	2	2	2	3	152
I_22979	Performing lateral positioning	508,125	1	6	6	7	7	8	1,637
I_23099	Attending to the tracheal cannula	12,412	2	5	8	8	8	14	71
I_23144	Performing venous blood collection	183,260	1	7	10	10	10	13	148
I_23331	Dispensing advice on falls	221,264	1	5	7	7	7	9	38
I_23424	Maintaining patient documentation	2,832,549	1	5	6	6	6	7	448

##### 4.1.1 Comparison of time values between hospitals

Experience has shown that the time spent on nursing care interventions varies between hospitals. In this section, we examine the extent to which this is true for the data under consideration. Table 6 provides an overview by hospital of the number of interventions that are less than, equal to, or greater than the corresponding median.<sup>6</sup> Time values that differ from the median by 30 seconds or less are treated as equal to the median. It turns out that at all hospitals, the majority of time values differed from the corresponding median by less than 30 seconds.

<sup>6</sup>The order is based on the Gini coefficient (e.g. James, Witten, Hastie, & Tibshirani, 2013, p. 312), so that hospitals with the largest differences between the three percentage values appear at the top.

Table 6: Percentage of interventions at each hospital that are less than, equal to, or greater than the median. The table is sorted by the Gini coefficient, so that hospitals with the largest differences between the three percentage values appear at the top.

Hospital	N	Less	Equal	Greater	Gini
P	1,693,917	0.1%	99.8%	0.1%	0.00
R	2,628,689	0.1%	99.8%	0.1%	0.00
A	691,163	0.1%	99.7%	0.2%	0.01
Q	3,126,479	0.1%	99.7%	0.2%	0.01
I	115,279	0.2%	99.6%	0.2%	0.01
D	989,520	0.3%	99.5%	0.2%	0.01
E	3,446,926	0.3%	99.3%	0.4%	0.01
L	6,505,318	0.2%	99.2%	0.7%	0.02
G	952,250	0.3%	99.0%	0.7%	0.02
H	74,452	0.6%	98.5%	0.9%	0.03
T	1,046,779	0.6%	98.3%	1.1%	0.03
M	18,868,885	2.0%	96.0%	2.0%	0.08
N	6,464,157	4.7%	90.5%	4.7%	0.18
K	2,537,972	7.0%	85.4%	7.6%	0.26
O	885,131	8.6%	81.8%	9.6%	0.31
C	8,950,026	8.7%	81.3%	10.0%	0.32
F	1,225,921	11.1%	77.2%	11.6%	0.38
S	967,080	14.2%	72.9%	12.8%	0.43
J	981,233	20.9%	65.4%	13.7%	0.51
B	21,759	23.0%	51.3%	25.7%	0.62

Similarly to Table 5, Table 7 presents examples of quartiles for the time values of two selected LEP IIDs, broken down by hospital. If a given hospital is not listed in Table 7 for a given LEP IID, this means that the intervention in question was not performed at that hospital.

Table 7: Quantiles of corrected LEP minutes for LEP nursing interventions by hospital.

IID	Description	Hospital	N	Min	25%	Median	75%	Max
I_22657	Performing a full body wash	Total	208,649	1	22	22	22	234
		A	3,045	22	22	22	22	30
		C	23,942	4	20	20	21	87
		D	1,980	10	22	22	22	22
		E	13,755	20	22	22	22	45
		F	1,798	3	16	18	20	102
		G	2,737	10	20	20	20	70
		H	178	22	22	22	22	22
		I	650	22	22	22	22	50
		J	1,519	4	34	38	50	152
		K	3,088	4	21	23	27	86
		L	21,002	10	22	22	22	65
		M	91,719	13	23	23	23	59
		N	9,656	1	24	25	29	260
		O	1,436	6	27	29	33	117
		P	5,754	22	22	22	22	30
Q	16,997	5	22	22	22	65		
R	4,033	10	25	25	25	30		
S	1,712	5	24	25	28	99		
T	3,648	23	23	23	23	23		

Continued



I_22876	Administering food	Total	135,119	2	10	10	10	335
		A	1,176	11	11	11	11	11
		C	8,224	1	6	7	8	51
		D	1,849	5	11	11	11	40
		E	7,059	11	11	11	11	30
		F	395	3	8	10	14	326
		G	1,238	10	10	10	10	15
		H	77	11	11	11	11	11
		I	145	11	11	11	11	11
		J	633	2	7	7	10	67
		K	581	2	7	7	8	37
		L	14,158	5	11	11	11	35
		M	75,883	11	11	11	11	50
		N	6,501	3	11	12	12	83
		O	532	4	11	12	14	62
		P	2,311	5	11	11	11	11
		Q	10,294	10	11	11	11	45
		R	959	10	20	20	20	45
		S	1,145	4	11	13	15	40
		T	1,959	10	11	11	11	30

#### 4.1.2 Evaluation of statistical correction

In this section, we check the robustness of the results by comparing the medians of the corrected LEP minutes used here (cf. Section chap. 3) with the medians of the raw data. In general, any differences should not be seen as calculation errors. These differences are due to the fact that effects relating to patients and nurses are factored out in the corrected LEP minutes.

*Table 8: Comparison of medians of corrected LEP minutes (standard method) with medians from raw data. Rows 1-3 show the percentages for which the medians of the corrected LEP minutes were smaller, equal or larger. Rows 4-8 show the quartiles of the differences between medians. These calculations cover medians for 516 LEP nursing care interventions.*

1	Median from standard method is smaller	22.3%
2	Median from standard method is equal	52.5%
3	Median from standard method is larger	25.2%
4	Max. negative difference btw medians (min)	-31.5
5	1st quartile of differences btw medians (min)	-0.4
6	Median of differences btw medians (min)	0.0
7	3rd quartile of differences btw medians (min)	0.5
8	Max. positive difference btw medians (min)	16

Table 8 provides an overview of the median comparisons. In 52.5% of cases, the medians are the same with both calculation methods, and the first and third quartiles of differences are also less than 1 minute. In contrast, the medians of the corrected LEP minutes are less than the median of the original LEP minutes for 22.3% of LEP IIDs, and greater for 25.2% of LEP IIDs. The medians differ by a maximum of -31.5 minutes (negative) and a maximum of 16 minutes (positive).

Table 9 shows LEP IIDs for which the medians from the raw data and those from the corrected LEP minutes differ by 5 minutes or more. This was the case for 24 interventions in all.

*Table 9: LEP nursing care interventions for which the calculation methods differ by 5 minutes or more. MD = Median.*

IID	Description	MD corr. LEP min.	MD raw data	Diff.
I_23319	Providing support during labour	31	15	16
I_23478	Remaining present in a supervisory capacity	21	10	11
I_23390	Providing 1:1 support	28	20	8
I_23035	Performing a special bath/shower	18	12	6
I_22968	Disinfecting the room	10	5	5
I_22646	Implementing leisure activities	15	10	5
I_22710	Implementing household training	20	15	5
I_23320	Providing primary post-partum support	25	30	-5
I_23110	Providing training in drinking/eating	15	20	-5
I_23036	Making a special bed	8	13	-5
I_23158	Implementing behaviour training	2	8	-6
I_22635	Conducting a feedback discussion	9	15	-6
I_23141	Holding a validating discussion	9	15	-6
I_22658	Preparing and subsequently attending to a birthing berth	23	30	-7
I_30720	Dispensing advice on everyday/activity planning	12	20	-8
I_23386	Carrying out household chores	7	15	-8
I_23385	Organising a household	7	15	-8
I_30772	Applying/removing bandage for negative pressure therapy	21	30	-9
I_23420	Preparing a plaster cast/splint	19	29	-10
I_23531	Implementing exposure training	14	30	-16
I_23339	Carrying out social setting-specific clarifications	8	25	-17
I_23091	Implement animal-supported therapy	22	45	-23
I_23544	Implementing therapeutic games	26	50	-24
I_22612	Implementing relaxation exercises	9	40	-31

The differences between the medians for the raw data and those for the corrected LEP minutes can be attributed either to the factoring out of patient or nurse effects, or to weighting in the calculation of the overall mean  $\beta_0$  (see Section 3.1). Table 10 makes this explanation somewhat clearer for IIDs with a difference of 15 minutes or more.

*Table 10: Details on LEP IIDs with large differences ( $\geq 15$  min.) between the medians from the raw data (MD raw data) and the corrected LEP minutes (MD corr.).  $N$  is the number of interventions,  $N_b$  is the number of patient/nurse combinations, and RMSE Patient and RMSE Nurse are the roots of the average squared deviations between the patient effects and nurse effects, respectively.*

IID	Description	Hospital	N	$N_b$	MD corr.	MD raw data	RMSE Patient	RMSE Nurse
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*Continued*

I_23319	Providing support during labour	Total	1,900	1,335	31	15		
		C	745	685	82	120	115.7	132.5
		K	1,125	620	12	15	9.1	12.6
		N	2	2	24	24		
		S	28	28	33	30	9.8	11.6
I_23531	Implementing exposure training	Total	360	22	14	30		
		F	5	4	10	5	5.0	
		G	20	9	11	10	1.8	
		M	334	8	26	30	26.4	
		S	1	1	5	5		
I_23339	Carrying out social setting-specific clarifications	Total	114	51	8	25		
		D	3	2	5	5		
		F	1	1	5	5		
		K	15	12	9	10	10.8	1.8
		L	10	10	5	5	0.0	
		M	62	3	25	25	0.0	
		S	23	23	10	10		
I_23091	Implement animal-supported therapy	Total	68	26	22	45		
		G	32	24	20	20	4.7	3.7
		M	36	2	45	45		
I_23544	Implementing therapeutic games	Total	7,421	285	26	50		
		C	565	142	16	20	41.8	28.0
		F	37	28	32	15	12.4	43.1
		J	1	1	10	10		
		K	1	1	5	5		
		M	6,803	99	50	50	14.6	0.0
		O	1	1	30	30		
		T	13	13	38	45	19.5	18.4
I_22612	Implementing relaxation exercises	Total	14,700	747	9	40		
		C	89	24	5	5	2.4	
		D	1	1	6	6		
		E	23	16	6	6	2.7	0.0
		F	5	5	15	15		
		G	87	65	12	10	9.4	50.9
		J	25	7	5	5	0.0	
		K	332	212	5	5	4.1	1.8
		L	1	1	10	10		
		M	14,076	379	11	40	151.2	0.8
		O	16	11	5	5	0.0	
		Q	4	4	6	6	0.0	
		S	41	22	6	5	6.4	0.8

For LEP intervention I\_23319, “Providing support during labour”, we see in the raw data that one hospital has a high median at 120 minutes, and that the patient and nurse effects also diverge sharply (RMSE

Patient = 115.7, RMSE Nurse = 132.5). Factoring out these effects brings the median down from 120 minutes to 82.3.

In calculating the overall median for IID I\_23319, a counter-effect arises as a result of weighting with  $N_b$ . For the median of the original LEP minute values, the hospital with  $N=1,125$  had the highest weight, and since this hospital had a low median (MD raw data = 15), the overall median was also low at 15 minutes. On the other hand, in the weighted calculation of  $\beta_0$ , the hospital mentioned in the previous section had the highest weight with MD corr. = 82.3 and  $N_b = 685$ . This explains why the correction caused the median to increase from 15 to 30.6 minutes. It is worth mentioning that the overall median would have increased much more sharply if the patient and nurse effects had not been factored out.

In the above example, both the factoring out of these effects and the weighted calculation of  $\beta_0$  contributed to the difference between the medians. In some cases, just one of these reasons predominates. With I\_23531 “Implementing exposure training”, for example, the medians barely change at the level of individual hospitals; however, the hospital with the most interventions ( $N=334$ ) has a relatively low weight with  $N_b = 8$  (i.e. many of the interventions were provided to the same patient or by the same nurse). For this IID, then, the difference between the median for the raw data and the median for the corrected LEP minute values is primarily explained by the weighted calculation of  $\beta_0$ .

**Correcting extreme values** In looking at the time value corrections, we note that certain large time values are corrected sharply upward or downward. Accordingly, the maxima of the corrected LEP minutes diverge sharply in some cases from the maxima of the original LEP minutes.

This effect is particularly striking in the case of IID I\_23390 “Providing 1:1 support”. Table 11 shows the medians and maxima for the corrected and original LEP minutes. Overall (first line), the maximum for the corrected LEP minutes (2,060 minutes) is almost twice as high as the maximum for the raw data (1,080 minutes). The maxima for the individual hospitals also vary quite sharply in some cases, although corrections are seen in both the upward (e.g. hospitals K, N and R) and downward directions (e.g. hospitals B, D, E, M and O).<sup>7</sup>

*Table 11: Differences in the maxima for LEP IID I\_23390. MD corr., Max corr: median and maximum of corrected LEP minutes, MD raw data, max. raw data: Median of corrected LEP minutes*

IID	Description	Hospital	N	MD corr.	MD raw data	Max corr.	Max raw data
I_23390	Providing 1:1 support	Total	55,239	28	20	2,060	1,080
		O	1,552	26	20	221	420
		S	3,355	24	20	289	310
		N	11,883	52	60	1,848	1,080
		C	6,580	31	20	842	500
		J	5,327	14	10	420	420
		B	2	112	225	112	420
		F	4,880	9	5	340	360
		K	8,351	24	15	1,765	580
		E	627	21	20	64	120
R	103	115	60	1,079	360		

*Continued*

<sup>7</sup>For the corrected LEP minute values, the maximum from the overall view (line 1) does not correspond to the maximum from the individual hospitals (lines 2 and below) because an additional step of calculation was applied in calculating the first line.

T	461	60	60	60	60
Q	118	30	30	58	60
L	3,355	24	20	333	420
G	1,657	58	60	262	200
P	65	20	20	60	60
A	1	10	10	10	10
M	6,838	38	50	326	960
D	84	21	20	64	240

In most cases, the maxima for the original and corrected LEP minute values do not diverge as sharply as with IID I\_23390. Nor do these divergences carry over to the medians that are ultimately used as default time values – or if so, only to a very limited extent. In any case, the maximum values of the corrected time values should not be interpreted too seriously. The calculation of corrected LEP minutes could also be modified for future studies to avoid excessive upward corrections.

## 4.2 Comparison with current default time values

Table 12 provides an overview of the current and new default time values and medians. Of the 442 comparable IIDs, 231 or 52.3% of the default time values are identical. Decreases and increases are approximately even, with a slight tendency toward increases (22.6% decreases vs. 25.1% increases). The current and new medians differ by a maximum of -31 minutes (negative) and a maximum of 19 minutes (positive).

*Table 12: Comparison of current and new default time values / medians. Rows 1-3 show the percentages for which the medians of the new default time values were smaller, equal or larger. Rows 4-8 show the quartiles of the differences between the default time values. These calculations cover medians for 442 LEP nursing care interventions.*

Number of comparisons	442
Current median is smaller	22.6%
Current median is equal	52.3%
Current median is larger	25.1%
Max. negative difference btw medians (min)	-31.0
1st quartile of differences btw medians (min)	0.0
Median of differences btw medians (min)	0.0
3rd quartile of differences btw medians (min)	0.8
Max. positive difference btw medians (min)	19

As a basis for discussion of these changes, Table 13 lists all IIDs for which the old and new default time values differ by more than 5 minutes. There are 23 such IIDs in all.

*Table 13: LEP nursing care interventions for which the old and new default time values / medians differ by 5 minutes or more. MD = median, N = number of interventions.*

IID	Description	MD current	MD new	Diff.	N current	N new
I_23320	Providing primary post-partum support	6	25	19	1,124	1,056

*Continued*

I_22658	Preparing and subsequently attending to a birthing berth	5	23	18	2,288	371
I_22494	Assisting in childbirth	16	26	10	1,067	778
I_22559	Conducting a CTG	2	12	10	7,478	18,087
I_22646	Implementing leisure activities	7	15	8	4,076	82,275
I_22727	Implementing humour therapy	5	13	8	970	35
I_23390	Providing 1:1 support	20	28	8	11,234	55,239
I_22501	Dispensing childbirth advice	6	12	6	3,077	442
I_22520	Implementing body/movement therapy	6	12	6	427	128
I_22662	Implementing memory training	5	11	6	116	1,229
I_22821	Performing phototherapy	5	11	6	1,013	834
I_22912	Locating a patient	5	11	6	1,324	1,820
I_23033	Facilitating a walk	11	17	6	2,362	28,192
I_23035	Performing a special bath/shower	12	18	6	179	160
I_23110	Providing training in drinking/eating	9	15	6	10,019	18,197
I_23167	Carrying out funeral preparations	15	21	6	212	381
I_23116	Performing an initial examination (E1) in newborns	10	4	-6	1,168	2,367
I_23158	Implementing behaviour training	8	2	-6	1,069	1,168
I_22573	Monitoring dialysis parameters	13	4	-9	1,390	988
I_23420	Preparing a plaster cast/splint	29	19	-10	309	146
I_22489	Chaperoning in the external environment	18	7	-11	398	1,614
I_23383	Implementing a musical/creative activity	24	9	-15	280	373
I_22710	Implementing household training	51	20	-31	239	88,866

It is worth discussing for individual cases whether the new default time values are actually more reliable than the existing ones. For example, the number of documented interventions for IIDs I\_22658 “Preparing and subsequently attending to a birthing berth” (increased from 5 to 23 min.), I\_22727 “Implementing humour therapy” (increased from 5 to 13 min.), I\_22501 “Dispensing childbirth advice” (increased from 6 to 12 min.), I\_22520 “Implementing body/movement therapy” (increased from 6 to 12 min.), and I\_23420 “Preparing a plaster cast/splint” (decreased from 29 to 19 min.) was significantly higher in the earlier study.

Conversely, there are also IIDs for which the new default time value appears to be more trustworthy due to larger volumes of data. This is particularly true for IIDs I\_22646 “Performing leisure activities” (increased from 7 to 15 min.), I\_23390 “Providing 1:1 support” (increased from 20 to 28 min.), I\_23033 “Facilitating a walk” (increased from 11 to 17 min.), and I\_22710 “Implementing household training” (decreased from 51 to 20 min.).

The differences between the existing and new default time values are probably partially related to differences between the hospitals. Table 14 shows the medians of the corrected time values per hospital for IIDs for which the new default time value differs from the current time value by 10 minutes or more.

Table 14: Details on LEP IIDs with large differences ( $\geq 10$  min.) between the old and new default time values / medians.  $N$  is the number of interventions,  $N_b$  is the number of patient/nurse combinations, and RMSE Patient and RMSE Nurse are the roots of the average squared deviations between the patient effects and nurse effects, respectively.

IID	Description	Hospital	N	$N_b$	MD	MD	RMSE Patient	RMSE Nurse
					current	new		
I_23320	Providing primary post-partum support	Total	1,056	1,041	6	25		
		C	667	654		41	45.9	103.9
		D	107	107		6		
		K	29	28		5	3.3	4.5
		P	5	5		6	0.0	
		Q	2	2		6	0.0	
		R	58	57		13	8.7	11.0
I_22658	Preparing and subsequently attending to a birthing berth	Total	371	363	5	23		
		C	50	48		16	6.6	8.1
		F	3	3		5	0.0	
		K	1	1		5		
		L	7	6		5	0.0	
		N	8	4		6	0.6	1.0
		S	302	301		26	8.4	8.9
I_22494	Assisting in childbirth	Total	778	766	16	26		
		C	553	544		31	44.0	56.3
		K	4	4		9	3.7	
		L	2	1		16		
		N	5	3		16	0.0	
		Q	3	3		16	0.0	
		S	211	211		23	12.5	7.1
I_22559	Conducting a CTG	Total	18,087	7,381	2	12		
		C	2,456	1,513		17	11.6	30.3
		D	5	4		2	0.0	0.0
		E	430	121		2	6.0	1.7
		G	200	91		10	3.0	0.0
		K	5,960	2,862		15	2.7	3.8
		M	4,855	451		15	9.7	14.8
		N	2,943	1,187		11	8.9	9.3
		Q	6	5		2	0.0	
S	1,232	1,147		5	3.2	4.7		
I_23420	Preparing a plaster cast/splint	Total	146	79	29	19		
		C	5	5		3	1.5	
		F	1	1		10		
		G	14	13		10	0.7	0.5
		L	72	41		29	0.0	0.0
		M	44	13		26	11.2	
		R	1	1		10		
S	9	5		12	27.9			
I_22489	Chaperoning in the external environment	Total	1,614	827	18	7		

Continued

		C	697	515		5	18.8	4.6
		E	1	1		10		
		F	97	86		17	12.6	9.4
		G	67	12		15	1.6	0.0
		K	8	6		8	7.8	
		L	16	14		20	11.8	
		M	324	33		18	16.0	37.2
		O	5	5		20		
		Q	18	17		18	0.0	
		R	370	127		10	5.1	0.0
		S	9	9		22	9.1	
		T	2	2		19	1.5	
I_23383	Implementing a musical/creative activity	Total	373	210		24	9	
		C	19	12		34	19.9	
		E	3	2		10		
		F	31	13		15		
		K	87	47		6	5.6	1.3
		O	88	48		5	3.2	0.4
		R	139	84		13	17.2	0.0
		S	6	4		4	3.1	
I_22710	Implementing household training	Total	88,866	1,537		51	20	
		F	11	5		10	8.2	
		G	85	74		30	28.1	23.6
		M	88,765	1,453		20	166.3	7.3
		R	1	1		15		
		T	4	4		45		

For the IID I\_22494 “Assisting in childbirth”, for example, we see that the increase from 16 to 26 minutes is primarily attributable to hospitals C and S. These hospitals have significantly higher medians, and are more heavily weighted due to their large Nbvalues. By contrast, the medians for hospitals D, K, P and Q are practically identical with the current default time value.

## 5 Survey

In addition to data collection to determine the default time values, the study also included a qualitative survey on hospitals’ handling of default time values and time values in day-to-day LEP documentation practices. In this section, we present the results of this survey.

The survey form is presented in Appendix A. The survey took place between early November 2021 and the end of February 2022, and was conducted online with the LimeSurvey tool.<sup>8</sup> In total, 31 hospitals were contacted by email and could participate by means of a survey code. To increase the participation rate, up to two reminders were sent after the initial invitation email. The survey was not anonymous, i.e. the survey data could be linked to the LEP data.

<sup>8</sup>See <https://www.limesurvey.org/>.



The survey was answered by 22 hospitals. 6 of these 22 participating hospitals took part in the survey only, and not in the collection of LEP data. These were hospitals that originally agreed to take part in the study, and were then unable to provide LEP data for various reasons. Of the 20 hospitals that took part in data collection, 16 took part in the survey and 4 did not.

All 22 hospitals that participated in the survey are included in the survey results presented below, i.e. even the hospitals that did not provide any data. This increases the number of observations, and in the authors' opinion there is no significant reason to include only the hospitals which took part in data collection.

### 5.1 Handling of default time values

Figure 6 shows the distribution for question A001: *At your hospital, can the LEP default time values be modified in the software?* From these results, we can conclude that the software generally allows for changes to the LEP default time values.

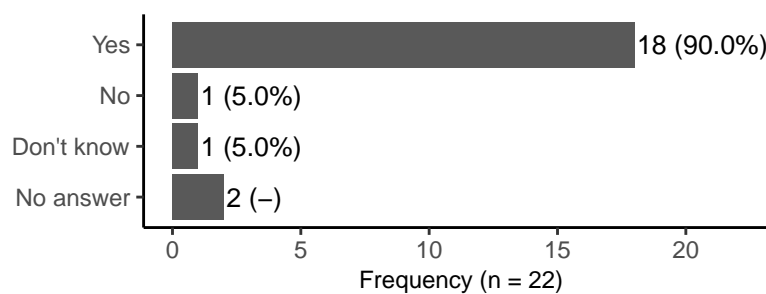


Figure 6: Distribution of answers to the question: "At your hospital, can the LEP default time values be modified in the software?".

Figure 7 shows the distribution for question A002: *At your hospital, were the LEP default time values actually modified?* Most hospitals answered in the affirmative (13 of 18 answers, or 72.2%). The explanation for the answer "Other" was that modifications were only made to self-defined interventions and those included in bulk interventions.

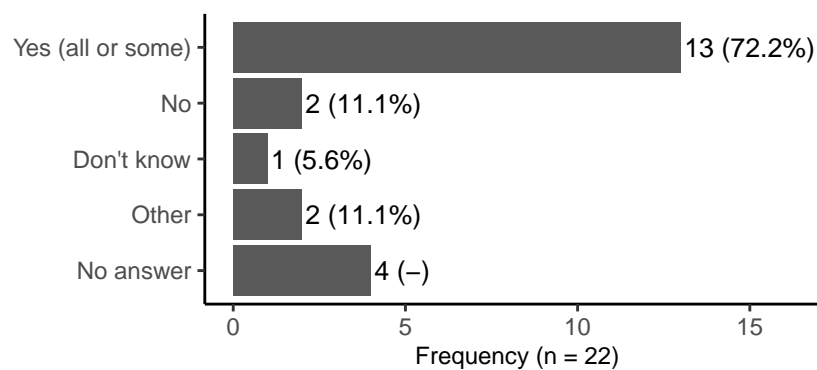


Figure 7: Distribution of answers to the question: "At your hospital, were the LEP default time values actually modified?".

Figure 8 shows the distribution for question A003: *Do you know which LEP services had their LEP default time values changed?* The percentages are approximately equivalent for the three answers “Yes”, “Partially”, and “No”.

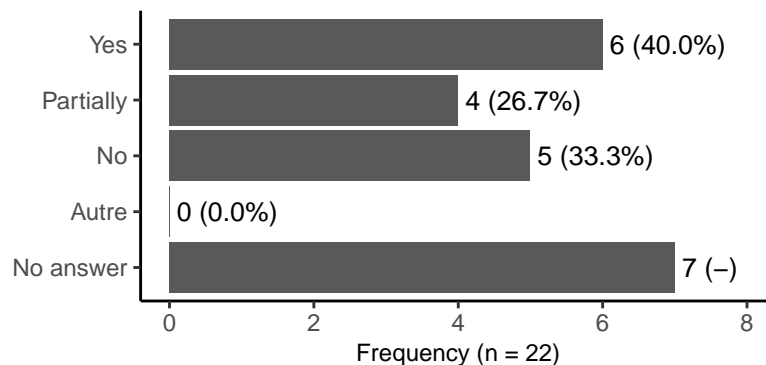


Figure 8: Distribution of answers to the question: “Do you know which LEP services had their LEP default time values changed?”.

In question A004, participants were asked whether a list of the default time values modified by the hospital could be provided. For this question, five of the 22 hospitals participating in the survey provided a list.

## 5.2 Handling of time values in day-to-day LEP documentation practices

Figure 9 shows the distribution for question B001: *At your hospital, can nurses change the time values in their day-to-day LEP documentation practices?* From these results, we can conclude that it is generally possible to modify the time values.

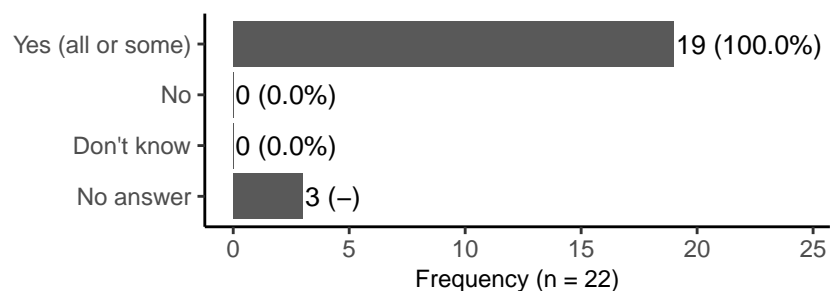


Figure 9: Distribution of answers to the question: “At your hospital, can nurses change the time values in their day-to-day LEP documentation practices?”.

Figure 10 shows the distribution for question B002: *Do you know for which LEP services the nursing staff are able to change the time values?* In most cases, there is at least partial awareness of which time values can be changed. However, there are also a few “No” answers and abstentions.

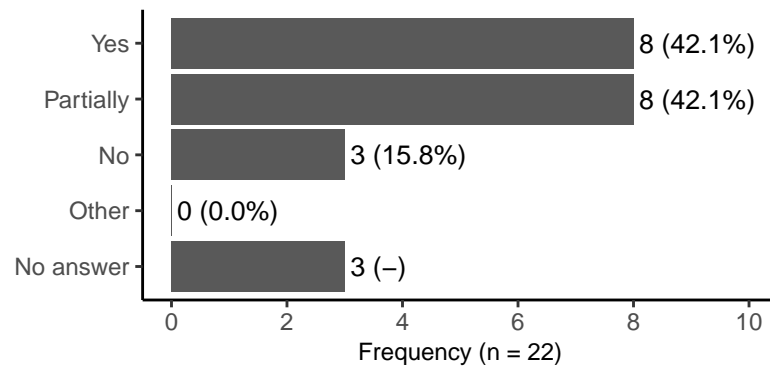


Figure 10: Distribution of answers to the question: "Do you know for which LEP services the nursing staff are able to change the time values?".

In question B003, participants were asked whether a list could be provided of the default time values that can be changed by nursing staff. For this question, only one of the 22 hospitals participating in the survey provided a list.

Figure 11 shows the distribution for question B004: *In which direction can the nursing staff change the time values?* Here we see that staff can generally change the time values in both the upward and downward directions.

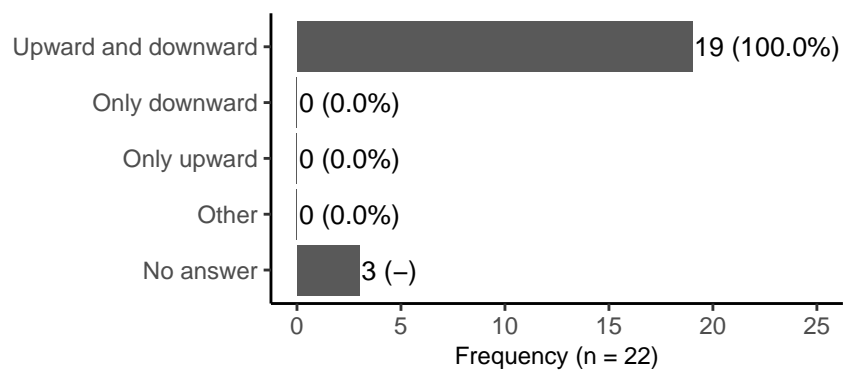


Figure 11: Distribution of answers to the question: "In which direction can the nursing staff change the time values?".

Figure 12 shows the distribution for question B005: *In your estimation, do the nurses change the time values in their day-to-day practice?* Here we see that a practice is established whereby time values are mostly changed only if the actual time spent diverges very strongly from the default time value.

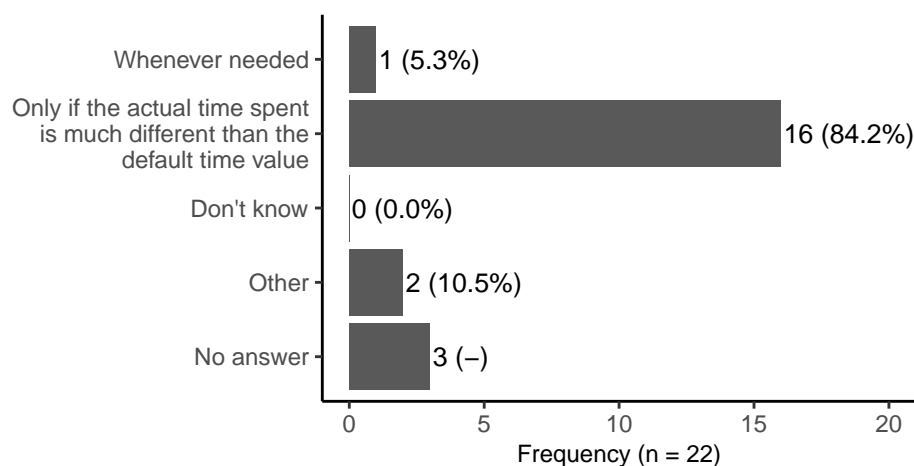


Figure 12: Distribution of answers to the question: “In your estimation, do the nurses change the time values in their day-to-day practice?”.

Table 15 shows comments from the participants who answered question B005: *In your estimation, do the nurses change the time values in their day-to-day practice?* with “Other”.

Table 15: Comments on the question: “In your estimation, do the nurses change the time values in their day-to-day practice?”.

- 
- 1 *Depends on the person: some do so very precisely, some not at all.*
  - 2 *Depends on the employee, but they are instructed to reliably adjust the time values.*
- 

## 6 Discussion

To identify default time values for LEP nursing interventions with case assignment on the basis of this study, data from 20 hospitals in Germany and Switzerland were analysed. After applying the inclusion criteria, approximately 62.2 million interventions with time values that were performed between 1 April and 30 September 2021 were included in the study.

To answer the first research question for this study, we have examined the distributions of default time values for 515 nursing care interventions from the current LEP version, Nursing 3.4.1, using quantiles (2.5%, 25%, 50%, 75% and 97.5%). The minimum and maximum of this distribution are not intended for further use, since they include outliers, e.g. those resulting from recording errors. In this study, they are only used to *illustrate* the extreme values.

The answer to the second research question is: Default time values could not be identified for all 575 nursing care interventions in Nursing 3.4.1 whilst applying the inclusion criteria. A total of 515 default time values resulted from the study, i.e. no default time values could be identified for 60 of the nursing care interventions. Setting aside existing default time values that could not be updated with this study, default time values exist for 530 IIDs, i.e. there are still 45 default time values missing.

These are presumably LEP interventions that are only used in specific care settings, e.g. interventions I\_22548 “Performing bronchial lavage” or I\_22986 “Performing Snoezelen therapy” were never performed

by the 20 participating hospitals or no data were provided for them. Or they may involve care settings that rarely occur in these 20 hospitals, e.g. interventions I\_22608 “Assisting with an endoscopy” or I\_22434 “Performing acupressure” were performed less than 30 times.

An additional conjecture is that no data or too little data were provided for the 40 new interventions in version 3.4.1 because they are largely unknown to the nursing staff. For example, I\_30700 “Performing therapeutic phlebotomy” was not documented by any of the 20 participating hospitals, and I\_30711 “Putting on/removing radiation protection equipment” only by 1 of them. On the other hand, another new intervention, I\_30773 “Performing urinary catheter care”, was documented by 8 hospitals and 40,223 times in total. The most commonly measured interventions were I\_22835 “Providing / clearing away a meal” (2,842,643 times) and I\_23424 “Maintaining patient documentation” (2,832,549 times). However, other interventions were also documented frequently and by all hospitals, e.g. I\_22642 “Providing / clearing away a beverage” (2,297,045 times) or I\_23170 “Carrying out a visit with a physician / treatment team” (1,370,556 times).

In certain individual cases, there are larger discrepancies between the current and new default time values. To ensure continuity with larger discrepancies, one option would be to only adopt the new default time values if they are definitely more accurate, e.g. if the new default time values are based on an equal or larger number of records than the existing default time values.

From the survey, we can see that software implementations of LEP generally allow for changes to LEP default time values and that hospitals make use of this option. It is also generally possible to adjust the time values in day-to-day LEP documentation practices, in both the upward and downward directions. As a rule, however, time values are only modified if the actual time spent diverges very sharply from the default time value. This is reflected in the data in that the distributions of LEP minute values often show an extreme modal value that exactly corresponds to the default value, cf. Figure 2. Therefore, the default time values determined by this study cannot be interpreted as the result of independent time measurement values, but rather as the current default time value plus some potential deviation due to the fact that the actual time spent often strongly deviated from the default time value in a particular direction (upward or downward), or because the hospitals use their own, significantly different default time values.

As part of the LEP release management process, the determined default time values will be systematically incorporated into the next version of LEP Nursing. The results can then be used as default values in software implementations of LEP. The rules on default time values must be respected in applying these values (Baumberger, Hieber, et al., 2016, p. 32–33, 105, 119 and 160).

For healthcare organisations and software companies that wish to begin using the newly determined default time values and integrate them into their LEP applications before the values are implemented as part of the regular LEP release management process, a list of the time values determined for the relevant LEP Nursing versions (3.1.0, 3.2.0 and 3.3.1) can be provided upon request.

**Recommendations** The default time values determined for the LEP interventions should continue to be reviewed at least every three years as part of the LEP release management process. The new default time values determined in this study should be taken into account for the next LEP version. New default time values that deviate sharply from the current default values should only be adopted if they are likely to be more accurate, e.g. if they are based on a larger number of records. For IIDs with no new default

time value, the current default time value should be kept. For now, the default time values that are still missing must be entered by the hospitals themselves. Based on results from subsequent studies, the missing default time values should be replaced as quickly as possible, or the reasons for their absence should be determined.

## **7 Future prospects**

This report has focused on the calculation of LEP default time values. However, the data collected for the study could allow for a deeper consideration of additional aspects that might help us to better understand LEP data and eventually support future studies on default time values.

In addition, the variables for areas of specialisation, ward type and staff category were not analysed in this study. This was not necessary because in this study, all participating organisations were able to deliver the anonymous identification numbers for nursing staff. This was not the case in the previous default time value study, and as a result, the combination of area of specialisation, ward type and staff category was used as a proxy for the nursing staff identification number. An analysis of these three variables could also help to better understand the heterogeneities in LEP minute values. Users report that LEP default time values are not appropriate for certain care settings; for example, the default time value of 10 minutes for I\_23451 "Attending to a wound" is generally not sufficient on a burn ward.

The survey yielded tables with information about modified default time values from individual hospitals. This information has not yet been analysed, and could help to better understand the heterogeneity of LEP minute values between different hospitals.

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## A Survey form

Thank you for participating in this survey about the LEP study “Identifying default time values for LEP nursing interventions”.

The purpose of this survey is to collect additional information about how time values and default time values are handled.

The survey will take about 5-10 minutes to complete. In addition, you may choose to voluntarily upload 2 files, which may take additional time.

Please contact info@lep.ch with any questions you may have.

This survey contains 9 questions.

### Handling of default time values

This group of questions looks at how default time values are handled in your organisation. Default time values are pre-defined standard values for the time spent on LEP services.

**A001** At your hospital, can the LEP default time values be modified in the software?

Yes  No  Don't know

*If you answer “Yes” to this question, the software used by your organisation provides the option to replace the LEP default time values with your own default time values. For the purposes of this question, it does not matter whether or not this option is used.*

**A002** At your hospital, were the LEP default time values actually modified?

*Answer this question only if the following conditions are met: Answer to question A001 was “Yes”*

Yes (all or some)  No  Don't know  Other: \_\_\_\_\_

*An example of a change would be if your organisation used a default time value of 20 minutes for the LEP service with IID I\_22434, “Performing acupuncture”, instead of 15 minutes (LEP default time value).*

*If you answer “Yes” to this question, then the default time value for one, several, or all LEP services has been changed in your organisation.*

*If you answer “No” to this question, then the LEP default time values were used for all LEP services in your organisation, even if there was technically an option to modify the default time values.*

**A003** Do you know which LEP services had their LEP default time values changed?

*Answer this question only if the following conditions are met: Answer to question A002 was “Yes (all or some)” or “Other”*

Yes  Partially  No  Other: \_\_\_\_\_

*If you answer “Yes” to this question, then your organisation has documentation (e.g. an Excel worksheet) indicating the LEP services (IIDs) for which the default time values have been changed, and*

*to what values they have been changed.*

*If you know that the default time values have been changed in your organisation, but there is no documentation of the changes, please answer "Partially".*

*If you have no knowledge as to whether the default time values have been modified, please answer "No".*

**A004** Would you be able to send us a list of the default time values that have been modified by your organisation? Sending the list is voluntary; if you do not wish to do so, please click "Next" to continue.

*Answer this question only if the following conditions are met: Answer to question A003 was "Yes" or "Other" or "Partially"*

*Only xlsx, csv, txt, pdf and docx formats can be accepted.*

*The following table format is recommended:*

- *Column 1: IID of the LEP service with a modified default time value (e.g. I\_22488)*
- *Column 2: Numerical value of the modified default time value in minutes (e.g. 20)*
- *Column 3: Comments*

*If default time values have been modified specifically for subgroups (e.g. for certain organisational units or staff categories), please document this in the "Comments" column. LEP services with multiple default time values can be represented with multiple rows.*

### **Handling of time values in day-to-day LEP documentation practices**

This group of questions considers the extent to which nursing staff can modify time values in their day-to-day LEP documentation practices.

**B001** At your organisation, can nurses change the time values in their day-to-day LEP documentation practices?

Yes (all or some)    No    Don't know

**B002** Do you know for which LEP services the nursing staff are able to change the time values?

*Answer this question only if the following conditions are met: Answer to question B001 was "Yes (all or some)" or "Other"*

Yes    Partially    No    Other: \_\_\_\_\_

**B003** Would you be able to send us your central documentation of the time values that can be modified by nursing staff? Sending this documentation is voluntary.

*Answer this question only if the following conditions are met: Answer to question B002 was "Yes" or "Partially" or "Other"*

*Only xlsx, csv, txt, pdf and docx formats can be accepted.*

*The following table format is recommended:*

- *Column 1: IID of the LEP service for which the time value can be modified by nursing staff (e.g. I\_22488)*
- *Column 2: Comments*

*If time values for individual LEP services can only be modified by specific subgroups (e.g. for certain organisational units or staff categories), please document this in the “Comments” column.*

**B004** In which direction can the nursing staff change the time values?

*Answer this question only if the following conditions are met: Answer to question B001 was “Yes (all or some)”*

Upward and downward    Only downward    Only upward    Other: \_\_\_\_\_

**B005** In your estimation, do the nurses change the time values in their day-to-day practice?

*Answer this question only if the following conditions are met: Answer to question B001 was “Yes (all or some)”*

Whenever needed    Only if the actual time spent is much different than the default time value  
 Don't know    Other: \_\_\_\_\_

Thank you for your participation.

If you made any mistakes while filling out the survey, you can click again on the link we sent you and correct your entries.

The results of this survey will be published as part of the study report on the LEP study “Identifying default time values for LEP nursing interventions”.

Have a great day!