Order picking is one of the most time-sensitive and cost-critical processes in warehousing, so researchers often focus on this warehouse operation. During this process, orders are retrieved from the warehouse storage to be shipped to customers. It is still applied manually in many warehouses, especially as the current trends, such as decreased product life cycle and increased product differentiation, amplify the need for flexible order picking systems and limit the possibility of automation. In these manual warehouses, picker-to-parts order picking is generally employed. Order pickers travel through the warehouse to collect requested products from the shelves following pre-determined routes. Researchers have developed numerous optimal and heuristic routing policies to guide order pickers efficiently. However, those routing policies often consider a single order picker in isolation or assume that multiple picker' routes are performed independently. In reality, numerous pickers travel through the warehouse simultaneously, and their routes can interfere. This phenomenon, called picker blocking, adds uncertainty to the picker routing problem and can lead to higher picking times than expected.

Using humans (i.e., order pickers) and their specific cognitive and physical skills to fulfill order picking activities makes the process more flexible. For example, when experiencing picker blocking, an order picker can independently decide to wait until the blockage is cleared or deviate from its planned route to avoid the blockage. On the other hand, these human workers' decisions introduce uncertainties in the order picking process. Our goal is to learn about these uncertainties during the order picking process. These insights can be used to include more real-life factors in future research. Numerous aspects can influence the order in which order pickers complete a pick tour and the time it takes to complete the pick tour. We analyze deviations in the order picking process in a broad sense by focusing on both deviations in picking order and in time.

Related work on deviations during the order picking process is limited. First, Glock et al. (2017) use a qualitative approach by conducting surveys to find the types, causes, and consequences. The authors conclude that, although positive effects are possible, the consequences of deviations on order picking efficiency are mainly negative. Second, Elbert et al. (2017) compared optimal and heuristic routing strategies while considering route deviations. To do this, the authors use agent-based simulation to analyze the effects of route deviations on picking time under different routing methods. A range of artificially selected probabilities determines whether a route deviation occurs. They conclude that it is essential to consider route deviations when determining the preferred routing strategy.

We improve warehousing research by analyzing historical data to quantify the prevalence of order picking deviations. Our contribution to order picking research is twofold. Firstly, a methodology to extract insights about order picking deviations from a data set is proposed. Until now, the existence of order picking deviations has only been indicated in survey results. However, a method to extract these insights from real-life data sets is still missing. Secondly, the proposed methodology is applied to a case study to analyze the real-life impact of order picking deviations. Currently, no data-based insights about order picking deviations exist. Implementing real-life factors in order picking research is necessary to make sure that outputs from order picking planning models resemble reality more closely, and it also increases the likelihood of warehouse managers implementing scientific research on warehousing. As the effects of order picking deviations are expected to be mainly negative, the overall warehouse performance will no longer be overestimated. This results in expectations from warehouse managers that are attainable for order pickers and, therefore, higher employee well-being and lower burn-out rates may be achieved.

As order picker deviations may manifest in different ways, the aim is to identify both deviations from the planned pick order of items (e.g., locations in a pick aisle were skipped because the aisle was

congested) and deviations from the expected times at which picks are performed (e.g., delays due to picker blocking or pickers taking alternative travel paths). Insights based on an extensive real-life data set will be presented.