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Analysis of Follow-up Times for Families Discharged from Opioid Addiction Treatment Facilities

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Abstract

Caregivers who receive treatment for opioid addiction often face adverse post-discharge incidents involving Children, Youth, and Family (CYF) services. These incidents can be traumatic for the children involved, potentially leading to the removal of a child from their home. Nonprofit social service organizations like Auberle aim to minimize these adverse events by implementing frequent follow-ups with discharged caregivers and their families.

We collaborated with Auberle social services (Pittsburgh, PA) and the Allegheny County Department of Human Services (DHS) to evaluate the effectiveness of standard follow-up times (7, 30, and 90 days post-discharge) in preventing CYF incident and to determine if implementing additional follow-ups may result in fewer CYF cases. Using data provided by the DHS, we constructed a mathematical function defining the probability that a CYF case will occur within one week of a follow-up. We then developed a stochastic algorithm to determine the optimal timing and impact of additional follow-ups.

Our results show that during the 90-day period where standard follow-up times were implemented, there were 43.3% fewer CYF cases than a 90-day period with no follow-ups. We found that if one additional follow-up is implemented, it should occur 160 days post-discharge and can reduce the total number of CYF cases by 9.3%. Alternatively, two additional follow-up times, occurring at 138 and 171 days post-discharge, can reduce the total number of CYF cases by 19.5%.

These findings can be used by Auberle to determine when their staff should follow-up with families discharged from the Family Healing Center, a new opioid treatment facility in the Mt. Oliver neighborhood of Pittsburgh.

1 Introduction

Amidst the current COVID-19 pandemic, the number of drug overdose deaths in the U.S. has risen drastically, hitting a record high of about 100,000 Americans between May 2020 and April 2021 [1]. This is a 28% increase from the previous year, which witnessed 78,000 overdose deaths, and is the most ever recorded in the U.S. during a single year [1]. The majority of these overdose deaths have been attributed to the use of opioids, a class of drugs commonly used to relieve pain [1]. Within the past decade, increased prescription and illicit use of opioids has fueled the deadliest drug epidemic in the U.S. [2].

According to health experts, while the opioid epidemic has been widely recognized as the deadliest drug epidemic and a national public health emergency in the U.S., its long-term impact on children and families at large, has been overlooked [2, 3]. In 2017, more than 2.2 million U.S. children had a parent struggling with opioid addiction or had their own addiction [3]. If trends continue, this number is estimated to reach 4.3 million by 2030 [3]. Of the 2.2 million U.S. children that were impacted by the epidemic in 2017, 325,000 children were involved in a Children, Youth, and Family (CYF) incident [3]. It is not uncommon for CYF cases and/or CYF placements to occur after a caregiver is discharged from an addiction treatment facility. CYF cases are alleged reports, claims, or alarming instances that warrant investigation by CYF authorities. In more severe cases, a CYF placement may follow in which the child is removed from their home and placed in foster care or with a relative. CYF incidents are especially traumatic for the children involved and may even increase the child's likelihood of suffering from future mental health or substance use disorders [4].

Unfortunately, Allegheny County, PA, which has an overdose death rate that is three times the national average, is no exception to this issue [5]. In fact, within the county, addiction has been cited as the primary reason that children are placed in care outside of their home [4]. One particular area in Allegheny County in which children and families are suffering the most from the opioid epidemic is Mt. Oliver [4]. To support these families, Auberle, a local nonprofit social service organization, is opening the Family Healing Center (FHC) in the Mt. Oliver neighborhood in August of 2022 [4]. The FHC is a licensed addiction treatment facility that will offer a level 3.5 treatment program (a clinically managed high-intensity residential program) for individuals struggling with severe addiction. This program will provide individuals with 24-hour supportive treatment to initiate or continue their recovery from addiction. Level 3.5 treatment programs provide individuals with regulated care from certified recovery specialists, counselors, and therapists without admittance to an inpatient facility or hospital [6]. Additional services, including family housing, family support specialists, onsite childcare services, evidence-based parent support programs, and transportation services, will be provided by Auberle's FHC to serve the families of those struggling with addiction [4, 6].

Auberle's mission is to provide positive outcomes for strong individuals and families in the community

[7]. To align with this mission, the FHC will focus on assisting caregivers with children under five years of age and providing services to these families to prevent future CYF incidents [4]. Auberle aims to minimize post-discharge CYF incidents by implementing frequent follow-ups with families discharged from the FHC. The standard protocol is to follow-up with families on 7, 30, and 90 days after discharge. To further Auberle's goal, this study aims to evaluate the standard protocol for follow-up visits and identify whether additional follow-ups may be beneficial in reducing the frequency of CYF cases and placements.

2 Project Overview

As mentioned above, Auberle's standard protocol is to follow-up with families on days 7, 30, and 90 following their discharge from the Family Healing Center (FHC). The objective of this study is to evaluate the effectiveness of these standard follow-up procedures in preventing CYF incidents and to determine the benefits of additional follow-up visits.

We collaborated with Auberle and the Allegheny County Department of Human Services (DHS) to obtain data on individuals who were admitted into a level 3.5 treatment facility in Allegheny County in 2019 and subsequently had a CYF case or placement after treatment. Using this data, we compared the number of CYF cases that occurred during the 90-day period in which standard follow-ups were implemented to the number of CYF cases that occurred during a 90-day period in which no follow-ups were implemented. Additionally, we constructed a mathematical function defining the probability of a CYF case occurring within 7 days of a follow-up visit. We then used this function to develop a stochastic algorithm to simulate the number of CYF cases that would occur if one or two additional follow-up visits were implemented. The results of this algorithm were used to determine the optimal timing of additional follow-up visits and to quantify the benefits of these additional follow-ups in reducing CYF cases.

We also studied the frequency of CYF placements after discharge and used this information to determine if and when additional follow-up visits should occur to reduce the likelihood of a CYF placement.

3 Data

The Allegheny County DHS provided us with data on 2,016 individuals who were admitted into a level 3.5 treatment program in Allegheny County (Pittsburgh, PA) in 2019. This data included the following information for each individual:

- Birth year
- Race

- Gender
- Date on which the individual was admitted into treatment
- Date on which the individual was discharged from treatment, and
- Start and end dates of any CYF cases and placements associated with the individual during the 1-year period after treatment.

Of the 2,016 individuals in our data set, 75 individuals had a CYF case after being discharged from a level 3.5 treatment program. Using the data provided, we calculated the following information for each of these 75 individuals:

- Age
- Length of treatment
- Length of time between discharge and a CYF case, and
- Length of time between a CYF case and a CYF placement (when applicable).

All data analyses and calculations were conducted using the statistical software R [8].

4 Analysis of Standard Follow-up Procedures

A primary objective of this study is to evaluate the effectiveness of the standard follow-up procedures in reducing CYF cases. To do this, we focused our attention on the 75 individuals in our data set who had a CYF case after discharge from level 3.5 treatment and created histograms displaying the frequency of CYF cases on the days following the individuals' discharge from treatment.

The histogram in Figure 1 shows the frequency of CYF cases during the first 120 days following discharge from level 3.5 treatment. Recall that the standard procedures are to follow-up with the individual on 7, 30, and 90 days after discharge. This histogram reveals that there are fewer CYF cases on and around standard follow-up times, which suggests that follow-up visits occurring on 7, 30, and 90 days after discharge *are* effective in reducing CYF cases in the short-term.

The histogram in Figure 2 shows the frequency of CYF cases during the 365 days following discharge from level 3.5 treatment. This histogram shows that of the 75 CYF cases that occurred within one year of discharge from level 3.5 treatment, 17 cases occurred during the 90-day period in which standard follow-ups were implemented and 58 cases occurred after the standard follow-up visits ended. Hence, the *majority* of CYF cases occurred after the first 90 days of discharge. Moreover, 30 CYF cases occurred between days 90

and 180 (compared to the 17 CYF cases that occurred during the first 90 days). Thus, we concluded that there were 43.3% fewer CYF cases during the 90-day period with follow-ups compared to a similar 90-day period with no follow-ups. These results reiterate the fact that follow-up visits *are* effective in reducing CYF cases and also highlight the need for additional follow-up visits beyond the first 90 days of discharge.

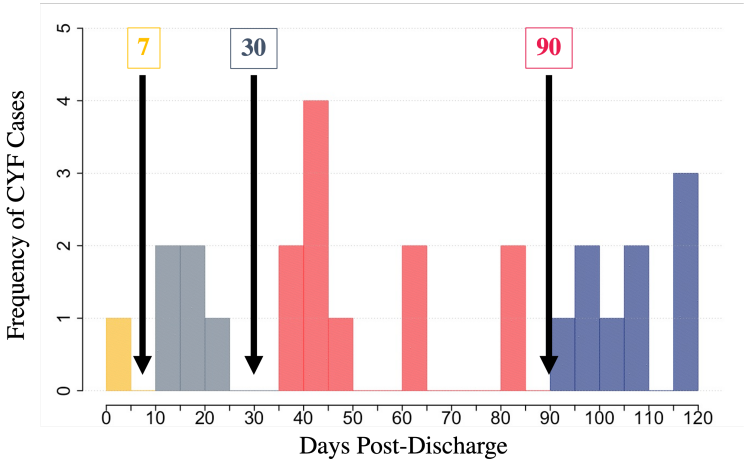

Figure 1: Frequency of CYF cases in the first 120 days post-discharge

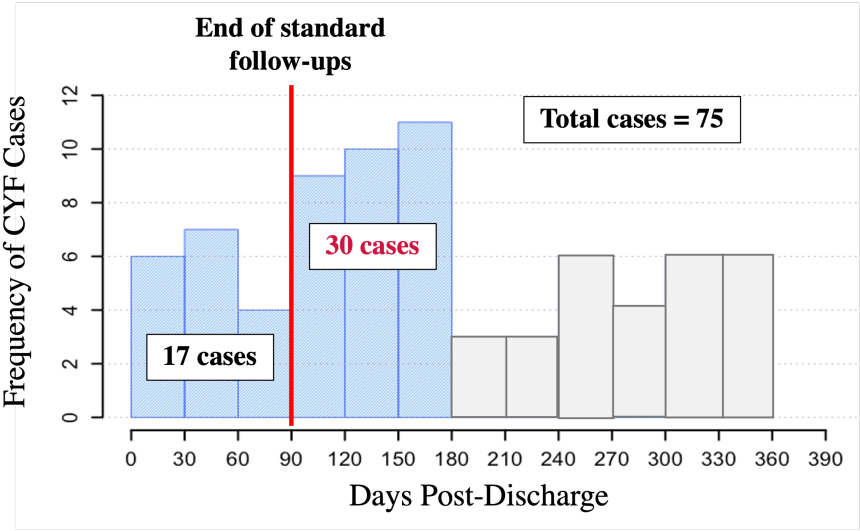

Figure 2: Frequency of CYF cases in the 365 days post-discharge

5 Additional Follow-ups to Prevent CYF Cases

5.1 Stochastic Algorithm

The second primary objective of this study is to determine if additional follow-up visits would be beneficial in reducing CYF cases. We developed a stochastic algorithm using R statistical software [8] to simulate and evaluate the impact of additional follow-up visits on CYF cases. A stochastic algorithm is a computational procedure that utilizes randomness. In our algorithm, randomness was included when simulating whether an additional follow-up visit would impact the likelihood of a CYF case.

First, we calculated the probabilities of a CYF case with and without a follow-up visit using our data. To calculate the probability of a CYF case in the absence of a follow-up visit, we used the data from days 100 to 190 in Figure 2. Over this 90-day period, there were 27 CYF cases. Thus, the daily probability of a CYF case in the absence of a follow-up visit was $\frac{27}{90} = 0.30$. This probability is indicated by the red line in Figure 3.

To calculate the probability of a CYF case in the presence of a follow-up visit, we used the data from days 1 to 100 in Figure 2. Based on our earlier findings, we assumed a follow-up visit can impact the likelihood of a CYF case occurring within the 7-day period before and the 7-day period after the visit. Thus, our first step was to find the total number of CYF that occur within 7 days of a standard follow-up visit on days 7, 30, and 90 post-discharge. Because there are three standard follow-up times, this value was divided by 3 to determine the average total number of cases occurring 1 to 7 days before or after a follow-up visit. We found this average to be 4.5. To calculate the probability of a CYF case on each of these 14 days, we divided the daily values by 4.5. The resulting daily probabilities are plotted as black circles in Figure 3. We then found the lines of best fit (blue lines in Figure 3) that describe the trend of these daily values during the 7-day period before and after a follow-up visit, respectively. These lines are described by equation $P(t)$ and represent the probability of a CYF case occurring within a 7-day period before or after a follow-up visit. As expected, the probability of a CYF case is zero on the day of a follow-up visit and increases as the length of time since the follow-up visit increases. Within the 7-day window of a follow-up, the probability of a CYF case occurring is strictly less than 0.30 (the probability of a CYF case in the absence of a follow-up). The function $P(t)$ is used in our stochastic algorithm to determine the likelihood of a CYF case occurring in the presence of an additional follow-up visit.

Second, we constructed a stochastic algorithm that incorporated the probability function, $P(t)$, to simulate the occurrence of CYF cases in the presence of one additional follow-up. As seen in the psuedocode in Algorithm 1, the algorithm calculates the total number of CYF cases that occur when one additional follow-up visit is implemented. We consider all possible follow-up times ranging from 1 to 365 days post-discharge.

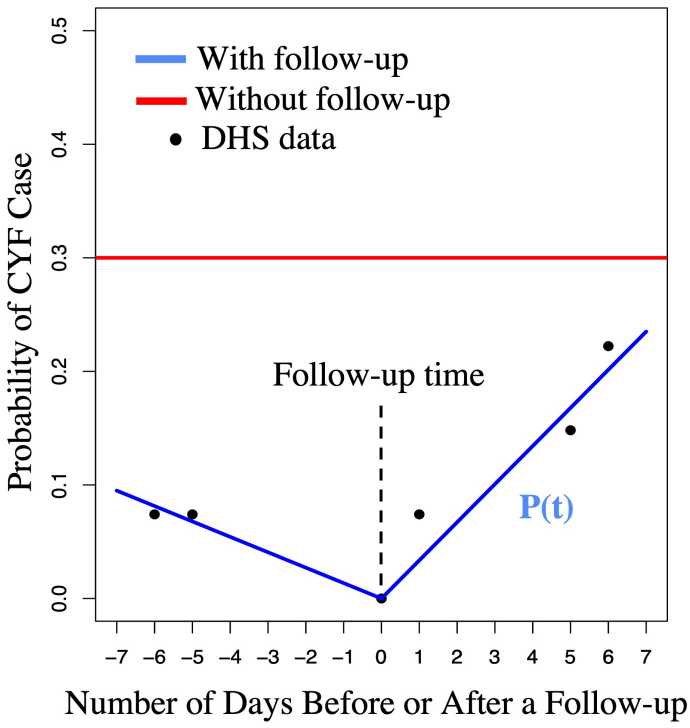

Figure 3: Probability of a CYF case occurring 7 days before or 7 days after a follow-up visit. Along the horizontal axis, the value $t = 0$ represents the day on which the follow-up visit occurs. Negative t values represent days prior to the visit and positive t values represent days after the visit.

For each of these potential follow-up times, the algorithm does the following. A counter representing the total number of CYF cases is set to zero. The inner for-loop iterates through all individuals in the population. For each individual, the length of time between the individual's discharge date and CYF case date is calculated and denoted by t. If t is within 7 days of the additional follow-up time, we calculate the probability that the individual's CYF case will still occur in the presence of the additional follow-up. This probability is calculated as $\frac{P(t)}{0.30}$ where $P(t)$ is the function presented in Figure 3 and 0.30 is baseline probability that the individual's case occurred. We then generate a random number r from a uniform distribution of values between 0 and 1. If $r \leq \frac{P(t)}{0.30}$, we assume the individual's CYF case occurs and therefore the total number of CYF cases is incremented by 1. If $r > \frac{P(t)}{0.30}$, we assume the individual's CYF case does not occur and therefore the total number of CYF cases remains the same. If t is not within 7 days of the additional follow-up time, the the additional follow-up visit does not impact the individual's likelihood of a CYF case and we assume the individual's CYF case occurs. This results in the total number of CYF cases being incremented by 1. When the inner for-loop has finished, the process repeats for a total of 10 trials, and the average number of CYF cases that occurs across all trials is calculated. Thus, the results of this algorithm provide

an average number of CYF cases expected for each of the 365 possible follow-up times. We seek to find the follow-up time that results in the minimum number of CYF cases.

We subsequently modified the algorithm to allow for two additional follow-up visits. In the modified version, the outer for-loop was altered to select two potential follow-up times, each ranging from 1 to 365 days post-discharge.

Algorithm 1 Stochastic Simulation of CYF Cases in the Presence of One Additional Follow-up Visit

for All additional follow-up times from 1 to 365 days post-discharge **do**
    Set total cases = 0
    for All individuals with CYF case **do**
        Let t = length of time between discharge and CYF case
        if t is within 7 days of additional follow-up **then**
            Calculate $P(t)/0.30$ (reduced probability of case)
            Let r = random number in [0,1]
            if $r <= P(t)/0.30$ **then**
                Increment total cases by 1
            end if
            if $r > P(t)/0.30$ **then**
                Total cases stays the same
            end if
        end if
        if t is **not** within 7 days of additional follow-up **then**
            Increment total cases by 1
        end if
    end for
    Repeat for 10 trials and calculate the average number of CYF cases
end for

5.2 Results from Simulations of One Additional Follow-up

The results of our stochastic algorithm implementing one additional follow-up visit are displayed in Figure 4. This graph shows the average number of CYF cases expected with one additional follow-up visit on one of days 1 through 365. The minimum number of CYF cases across all possible follow-up times is 68 and occurs 160 days post-discharge. Thus, if one additional follow-up visit is implemented on day 160, we would expect a 9.3% reduction in CYF cases (compared to the 75 cases that occurred with no additional follow-up).

5.3 Results from Simulations of Two Additional Follow-ups

Modifications were made to Algorithm 1 to allow for two additional follow-up visits. The results of the modified algorithm revealed that, over all possible combinations of follow-up times, the minimum number of CYF cases is 60, which occurs when the follow-up visits are implemented at 138 and 171 days post-discharge. Thus, if two additional follow-up visits are implemented on days 138 and 171, we would expect a

19.5% reduction in CYF cases (compared to the 75 cases that occurred with no additional follow-up). Table 1 summarizes these results.

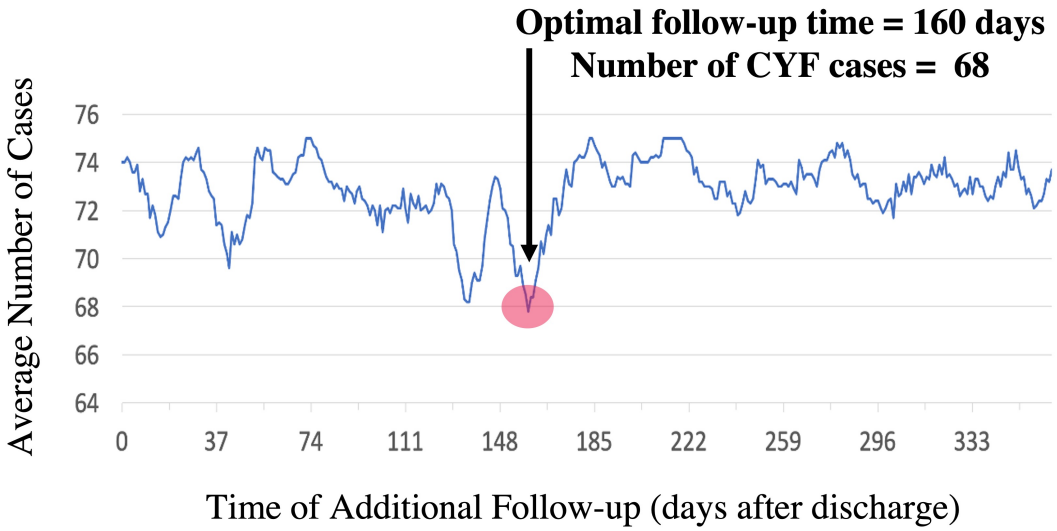

Figure 4: Average number of CYF cases expected with one additional follow-up

Follow-up Procedure	**Optimal Time (days after discharge)**	**Number of CYF Cases**
Standard 1 Standard 2 Standard 3	7 30 90	75
One additional	160	68 (9.3% reduction)
Two additional	138 and 171	60 (19.5% reduction)

Table 1: Impact of additional follow-ups on CYF cases

6 Additional Follow-ups to Prevent CYF Placements

As mentioned previously, Auberle aims to minimize *all* CYF incidents, which include cases *and* placements. Hence, we decided to determine if any observations could be made regarding the prevention of CYF placements (the most severe CYF outcome). To do this, we studied the length of time between a CYF case and a placement. Figure 5 shows the frequency of CYF placements on the days following a CYF case. Of the 75 individuals in our data set with a CYF case after treatment, 26 had a CYF placement. We observed that most CYF placements occur within 30 days after a CYF case. This result suggests that if a CYF case does occur, there is a need for additional follow-ups in the 30-day period following the case in order to prevent a CYF placement.

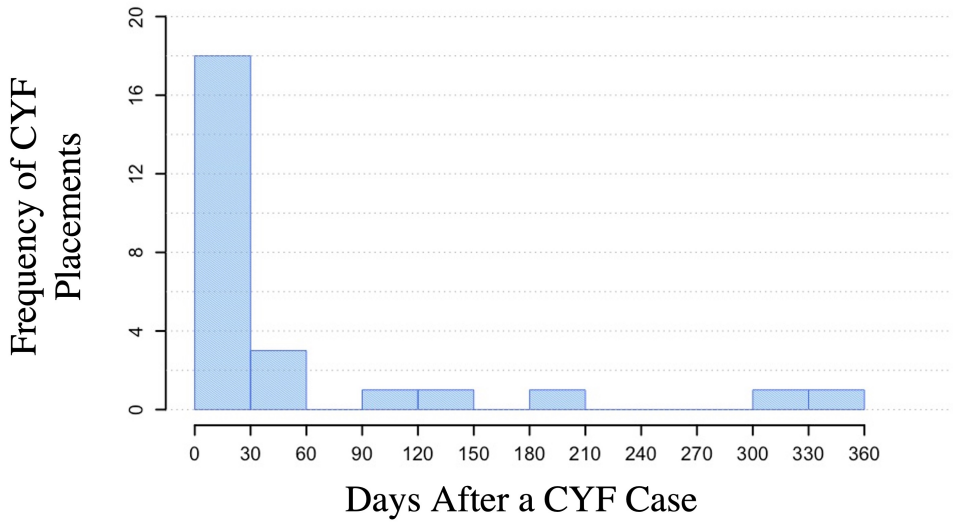

Figure 5: Length of time between CYF case and CYF placement

7 Conclusions and Implications

In collaboration with Auberle social services (Pittsburgh PA) and the Allegheny County Department of Human Services, we evaluated the effectiveness of standard follow-up procedures for individuals discharged from level 3.5 treatment programs and investigated whether additional follow-up visits could be beneficial in reducing Child, Youth, and Family (CYF) cases and placements.

Our results show that during the 90-day period in which standard follow-up times were implemented, there were 43.3% fewer CYF cases than the 90-day period with no follow-ups. Hence, follow-up visits occurring at standard times (7, 30 , 90 days post-discharge) *are* effective in reducing CYF cases. Further, we found that additional follow-up visits after the first 90 days of discharge are beneficial and can result

in a significant reduction in CYF cases. Implementing one additional follow-up at 160 days post-discharge can result in a 9.3% reduction in CYF cases. Alternatively, two additional follow-up visits, occurring at 138 and 171 days post-discharge, can result in a 19.5% reduction in CYF cases. Furthermore, we observed that most CYF placements occur within 30 days of a CYF case. Thus, if a CYF case does occur, we concluded that additional follow-up visits within 30 days should occur to prevent a placement (the most severe CYF outcome).

These findings can be used by Auberle to determine when their staff should follow-up with families discharged from the Family Healing Center (FHC) in order to minimize adverse post-discharge CYF incidents. Minimizing CYF cases and placements of families served by the FHC will increase the overall efficiency of the FHC as well as the impact of the FHC on the community. Additionally, by minimizing adverse post-discharge outcomes, Auberle will enhance the FHC's reliability and will further distinguish the FHC as an effective level 3.5 treatment program in Allegheny County. Consequently, the number of grants and donations received may increase, enabling Auberle to continue to thrive as a nonprofit social service organization. With increased financial support, Auberle may be able to further expand the FHC to serve *all* families in need of level 3.5 treatment in Allegheny County and most importantly, to reduce the number of children and families affected by the opioid epidemic [4].

8 Acknowledgements

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